# prova

February 10, 2023

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib as mplt
import seaborn as sns
import arviz as az
import datetime
```

[2]:
```
import fit_arima
```

[3]:
```
import open_data
df = open_data.open()
```

[4]:
```
ritorno = fit_arima.compute(2, 1, catene=4, samples_per_chain=2500, burnin=1000)
```

```
21:10:52 - cmdstanpy - INFO - CmdStan start processing

chain 1 |          | 00:00 Status

chain 2 |          | 00:00 Status

chain 3 |          | 00:00 Status

chain 4 |          | 00:00 Status


21:38:05 - cmdstanpy - INFO - CmdStan done processing.
21:38:05 - cmdstanpy - WARNING - Non-fatal error during sampling:
Exception: normal_lpdf: Scale parameter is -0.111703, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.s
tan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[2][11] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/ARIMA_l
ast_computation/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: code_model_namespace::log_prob: phi[1][1] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
ARIMA_last_computation/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: code_model_namespace::log_prob: phi[1][33] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/ARIMA_l
ast_computation/NoCovariates/code.stan', line 83, column 2 to column 47)
```

```
Exception: normal_lpdf: Scale parameter is 0, but must be positive! (in '/home/b
r1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.stan',
line 157, column 4 to column 34)
        Exception: normal_lpdf: Scale parameter is 0, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.s
tan', line 157, column 4 to column 34)
        Exception: normal_lpdf: Scale parameter is 0, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.s
tan', line 157, column 4 to column 34)
        Exception: code_model_namespace::log_prob: phi[2][8] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
ARIMA_last_computation/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: normal_lpdf: Scale parameter is 0, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.s
tan', line 157, column 4 to column 34)
        Exception: normal_lpdf: Scale parameter is -0.00468339, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.00781159, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
Exception: normal_lpdf: Scale parameter is -19.3346, but must be positive! (in '
/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.st
an', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -20.4458, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -1.84055, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[2][4] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
ARIMA_last_computation/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: normal_lpdf: Scale parameter is -9.85741, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.00793045, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
Exception: normal_lpdf: Scale parameter is -1.48033, but must be positive! (in '
/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/code.st
an', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.370182, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -3.13815, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
```

```
        Exception: normal_lpdf: Scale parameter is -2.7382, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.274406, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[1][10] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
ARIMA_last_computation/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: normal_lpdf: Scale parameter is -3.44707, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.00909615, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.0018971, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCov
ariates/code.stan', line 143, column 4 to column 61)
Consider re-running with show_console=True if the above output is unclear!


/home/br1/PythonProjects/PythonStats/ARIMA_last_computation/NoCovariates/fit_ari
ma.py:37: FutureWarning: Indexing with a float is deprecated, and will raise an
IndexError in pandas 2.0. You can manually convert to an integer key instead.
  y_missing_list.append({'Stazione':df.columns[v[i]],'Data':df.index[u[i]],'Samp
les':inference_data.posterior.w.values[:,:,i].reshape(catene*samples_per_chain)}
)
```

Tempo di computazione: 27:12

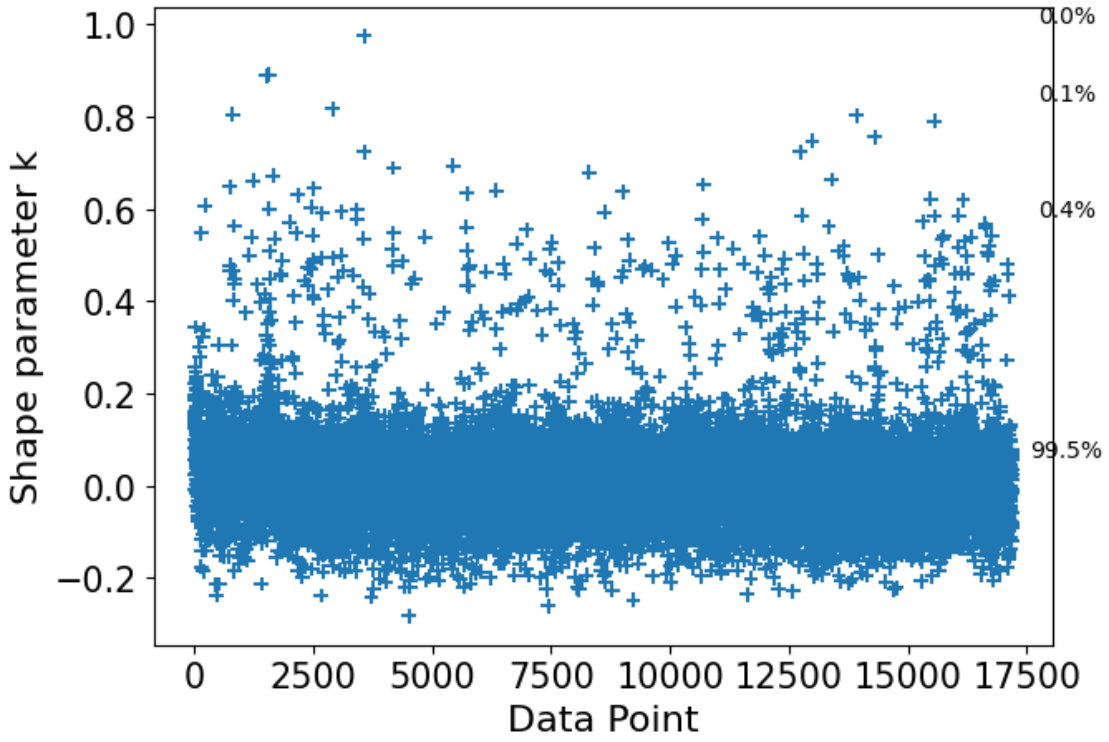
[5]:
```
res = az.loo(ritorno['inference_data'], var_name="log_lik", pointwise=True,␣
↪scale='deviance')
res
```

```
/home/br1/PythonProjects/PythonStats/.venv/lib/python3.10/site-
packages/arviz/stats/stats.py:803: UserWarning: Estimated shape parameter of
Pareto distribution is greater than 0.7 for one or more samples. You should
consider using a more robust model, this is because importance sampling is less
likely to work well if the marginal posterior and LOO posterior are very
different. This is more likely to happen with a non-robust model and highly
influential observations.
  warnings.warn(
```

[5]:
```
Computed from 10000 posterior samples and 17191 observations log-likelihood
matrix.

              Estimate       SE
deviance_loo -14506.23   309.87
```

```
p_loo          296.12        -

There has been a warning during the calculation. Please check the results.
------

Pareto k diagnostic values:
                         Count   Pct.
(-Inf, 0.5]   (good)     17112   99.5%
 (0.5, 0.7]   (ok)          68    0.4%
   (0.7, 1]   (bad)         11    0.1%
   (1, Inf)   (very bad)     0    0.0%
```

[6]:
```
aux_plt = az.plot_khat(res, show_bins=True, figsize=(7,5))
```

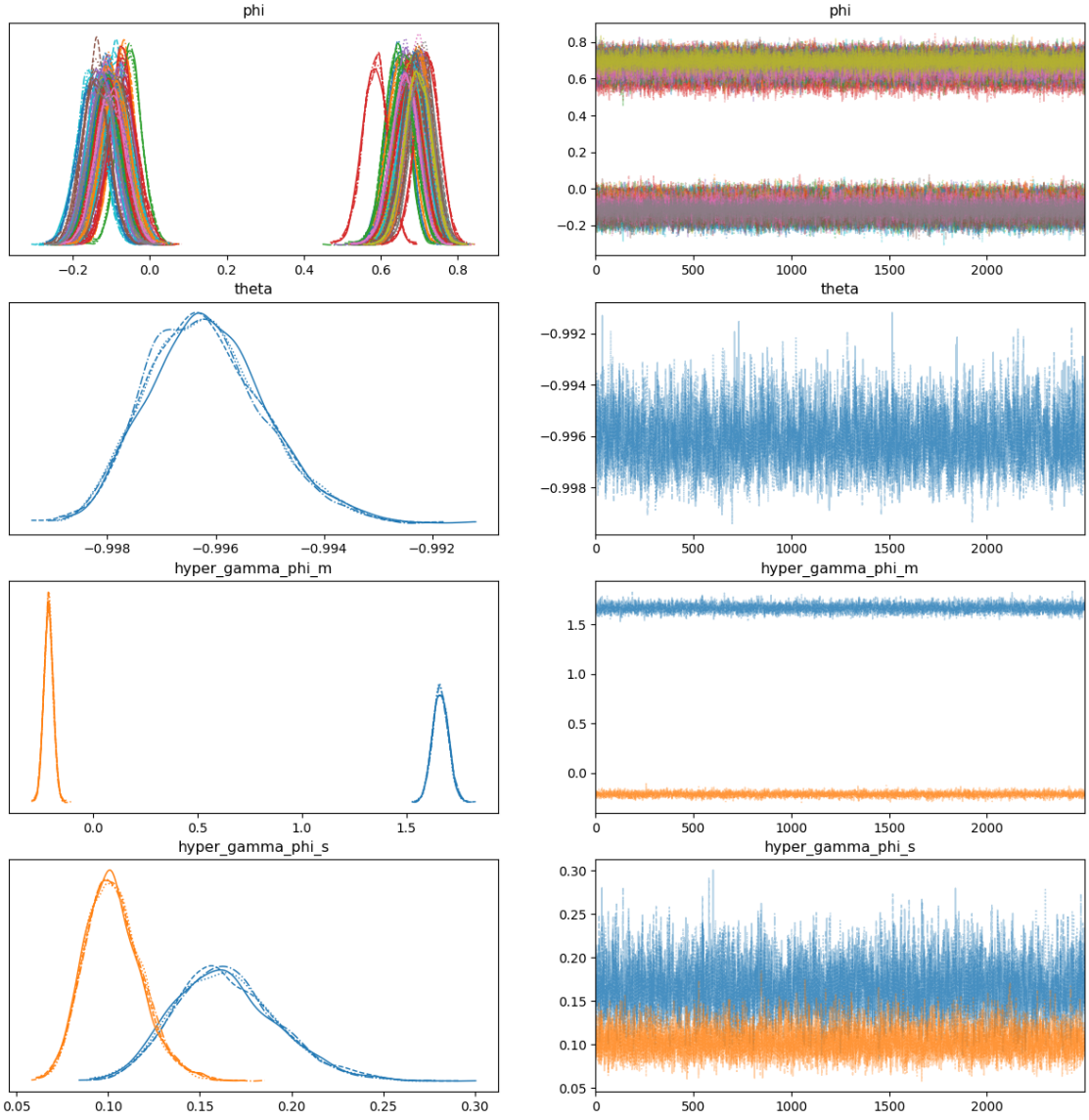



[7]:
```
res = az.waic(ritorno['inference_data'], var_name="log_lik", scale='deviance')
res
```

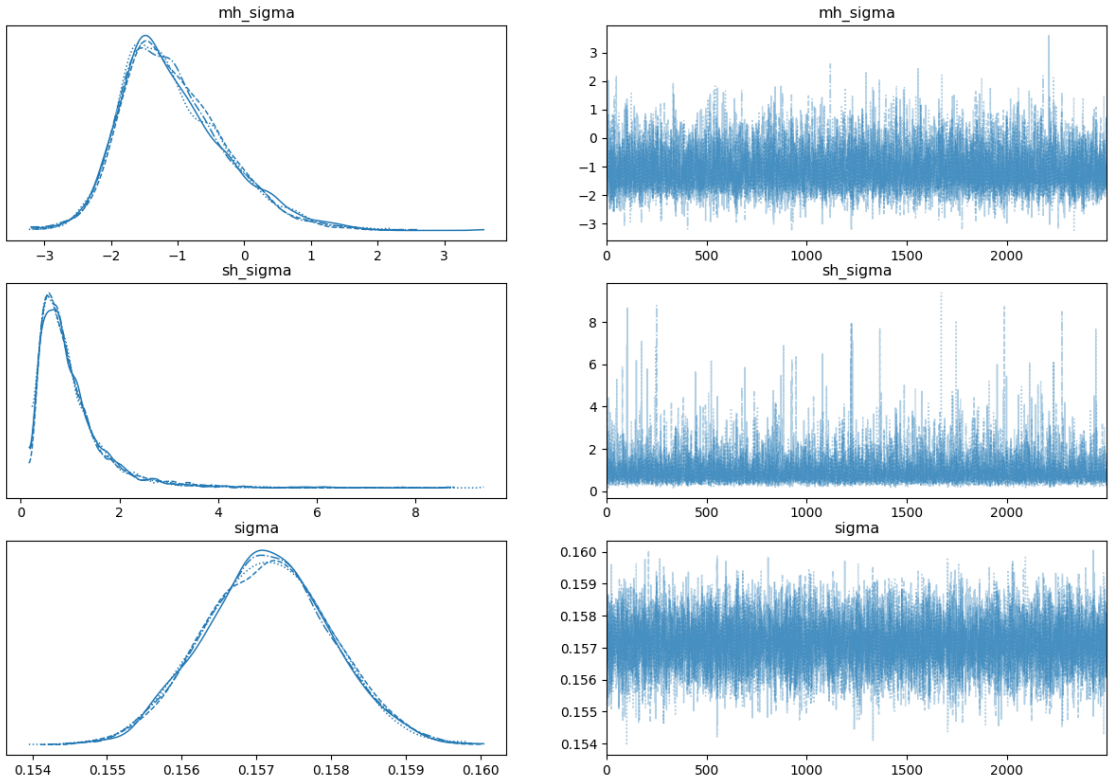
```
/home/br1/PythonProjects/PythonStats/.venv/lib/python3.10/site-
packages/arviz/stats/stats.py:1645: UserWarning: For one or more samples the
posterior variance of the log predictive densities exceeds 0.4. This could be
indication of WAIC starting to fail.
See http://arxiv.org/abs/1507.04544 for details
  warnings.warn(
```

[7]:
```
Computed from 10000 posterior samples and 17191 observations log-likelihood
matrix.

                Estimate       SE
deviance_waic -14528.97   309.61
p_waic          284.76        -

There has been a warning during the calculation. Please check the results.
```

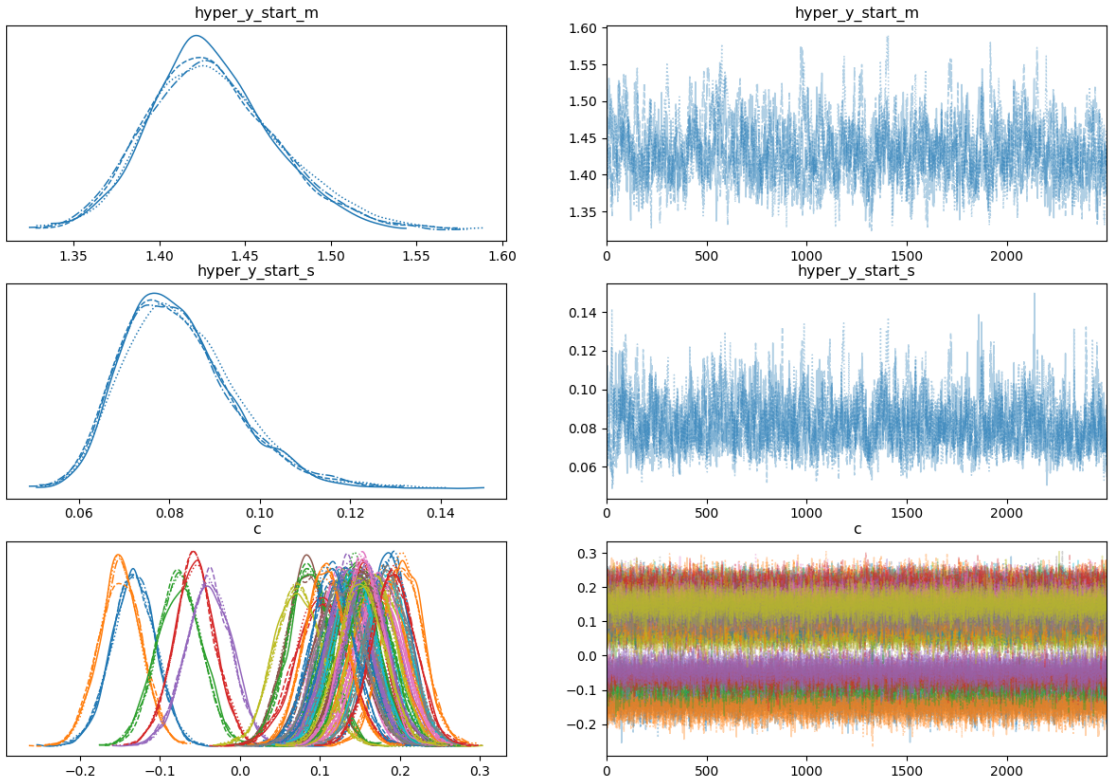
[8]:
```
plt_aux = az.plot_trace(ritorno['inference_data'],␣
↪var_names=['phi','theta','hyper_gamma_phi_m','hyper_gamma_phi_s'],␣
↪divergences=True, figsize=(15,15))
```



[9]:
```
plt_aux = az.plot_trace(ritorno['inference_data'],␣
↪var_names=['mh_sigma','sh_sigma','sigma'], divergences=True, figsize=(15,10))
```




[10]:
```
plt_aux = az.plot_trace(ritorno['inference_data'],␣
↪var_names=['hyper_y_start_m','hyper_y_start_s','c'], divergences=True,␣
↪figsize=(15,10))
```




[11]:
```
az.summary(ritorno['inference_data'],var_names=['y_start'])
```

[11]:

| | mean | sd | hdi_3% | hdi_97% | mcse_mean | mcse_sd | ess_bulk | ess_tail | r_hat |
|---|---|---|---|---|---|---|---|---|---|
| y_start[0, 0] | 1.422 | 0.089 | 1.251 | 1.587 | 0.002 | 0.001 | 2935.0 | 3563.0 | 1.0 |
| y_start[0, 1] | 1.419 | 0.091 | 1.248 | 1.591 | 0.002 | 0.001 | 3125.0 | 3114.0 | 1.0 |
| y_start[0, 2] | 1.422 | 0.090 | 1.252 | 1.593 | 0.002 | 0.001 | 3105.0 | 4272.0 | 1.0 |
| y_start[0, 3] | 1.424 | 0.090 | 1.253 | 1.594 | 0.002 | 0.001 | 3232.0 | 3953.0 | 1.0 |
| y_start[0, 4] | 1.427 | 0.092 | 1.245 | 1.595 | 0.002 | 0.001 | 2847.0 | 3181.0 | 1.0 |
| … | … | … | … | … | … | … | … | … | … |
| y_start[2, 44] | 1.445 | 0.054 | 1.345 | 1.548 | 0.001 | 0.001 | 1875.0 | 2333.0 | 1.0 |
| y_start[2, 45] | 1.442 | 0.055 | 1.340 | 1.549 | 0.001 | 0.001 | 1967.0 | 2333.0 | 1.0 |
| y_start[2, 46] | 1.438 | 0.054 | 1.334 | 1.535 | 0.001 | 0.001 | 2333.0 | 2333.0 | 1.0 |
| y_start[2, 47] | 1.452 | 0.055 | 1.348 | 1.556 | 0.001 | 0.001 | 1877.0 | 2333.0 | 1.0 |
| y_start[2, 48] | 1.459 | 0.057 | 1.360 | 1.572 | 0.001 | 0.001 | 1908.0 | 2333.0 | 1.0 |

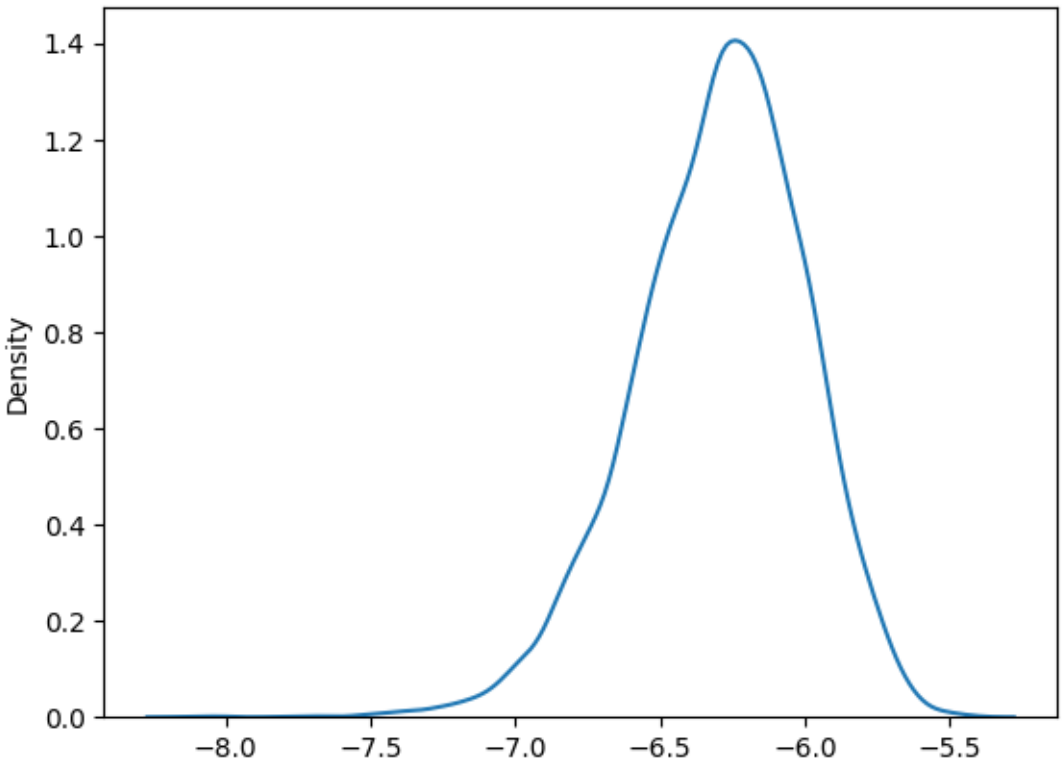
```
y_start[2, 44]    2615.0    1.0
y_start[2, 45]    2244.0    1.0
y_start[2, 46]    3204.0    1.0
y_start[2, 47]    2748.0    1.0
y_start[2, 48]    2766.0    1.0

[147 rows x 9 columns]
```

[12]:
```
az.summary(ritorno['inference_data'], var_names=['hyper_y_start_m',␣
 ↪'hyper_y_start_s'])
```

[12]:
```
                 mean     sd  hdi_3%  hdi_97%  mcse_mean  mcse_sd  ess_bulk  \
hyper_y_start_m  1.432  0.038   1.364    1.506      0.002    0.001     578.0
hyper_y_start_s  0.082  0.012   0.061    0.106      0.000    0.000     688.0

                 ess_tail  r_hat
hyper_y_start_m     852.0   1.00
hyper_y_start_s    1692.0   1.01
```

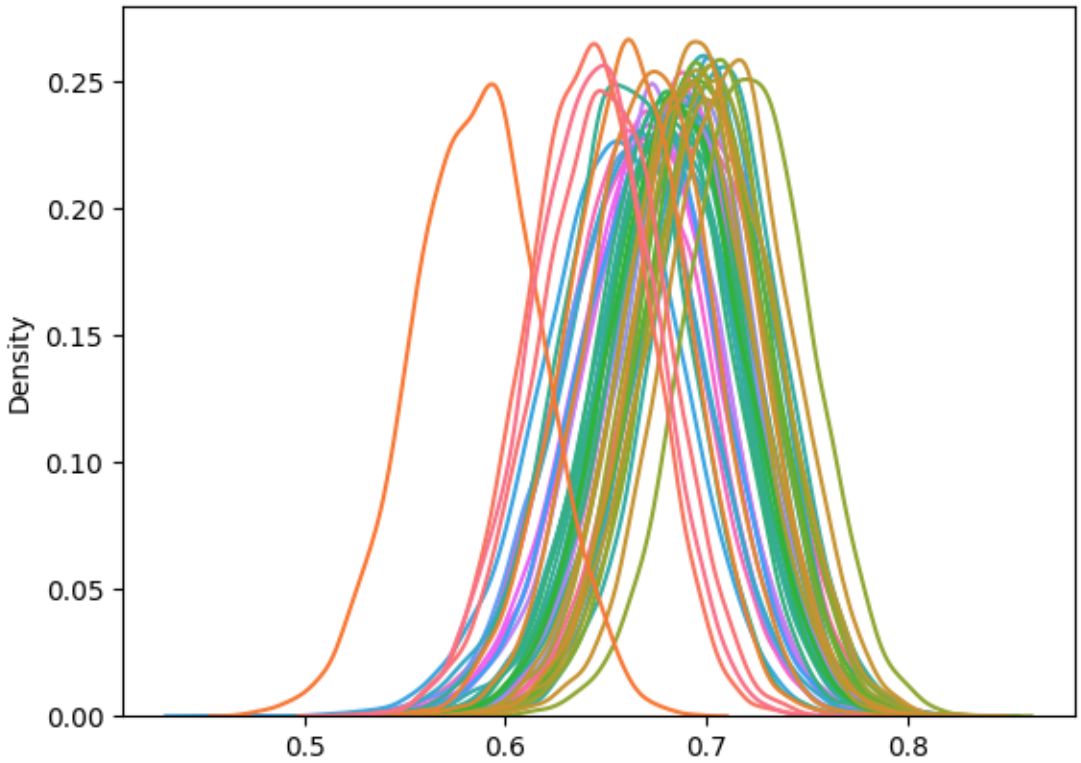
[13]:
```
aux_shape = ritorno['inference_data'].posterior.gamma_th.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.gamma_th.values.
 ↪reshape((aux_shape[0]*aux_shape[1])), legend=False)
```

[13]:
```
<AxesSubplot: ylabel='Density'>
```



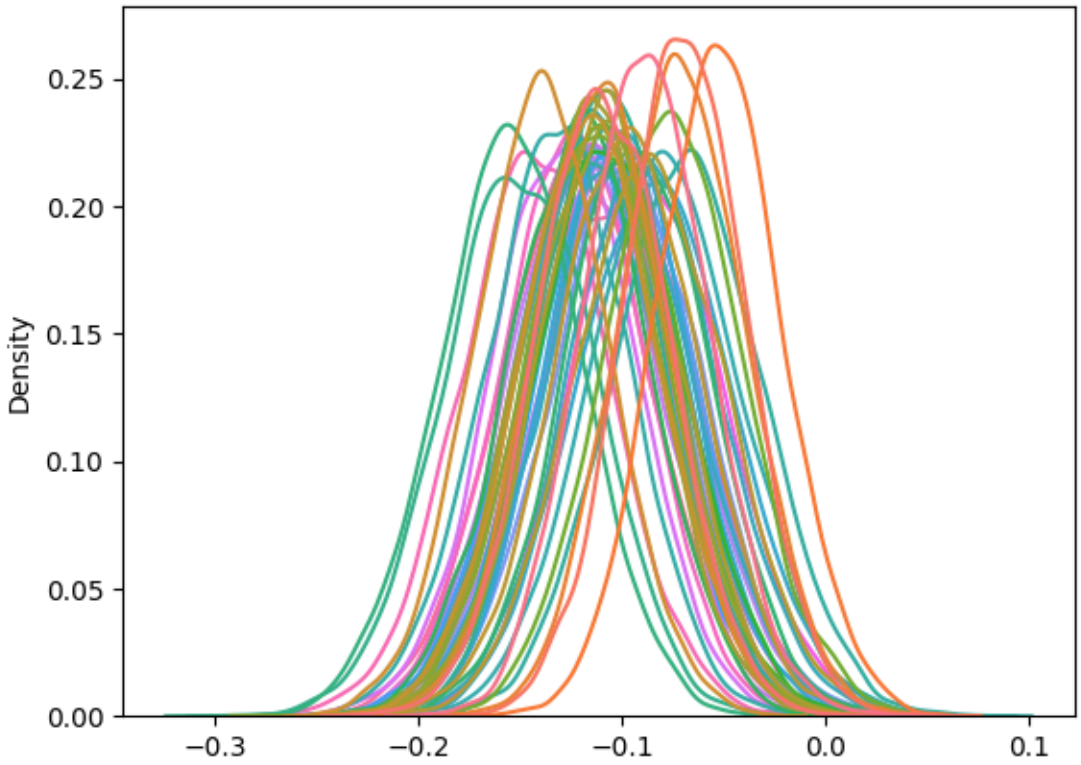
[14]:
```
aux_shape = ritorno['inference_data'].posterior.phi.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.phi.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2],aux_shape[3]))[:,0,:],␣
  ↪legend=False)
```

[14]:
```
<AxesSubplot: ylabel='Density'>
```



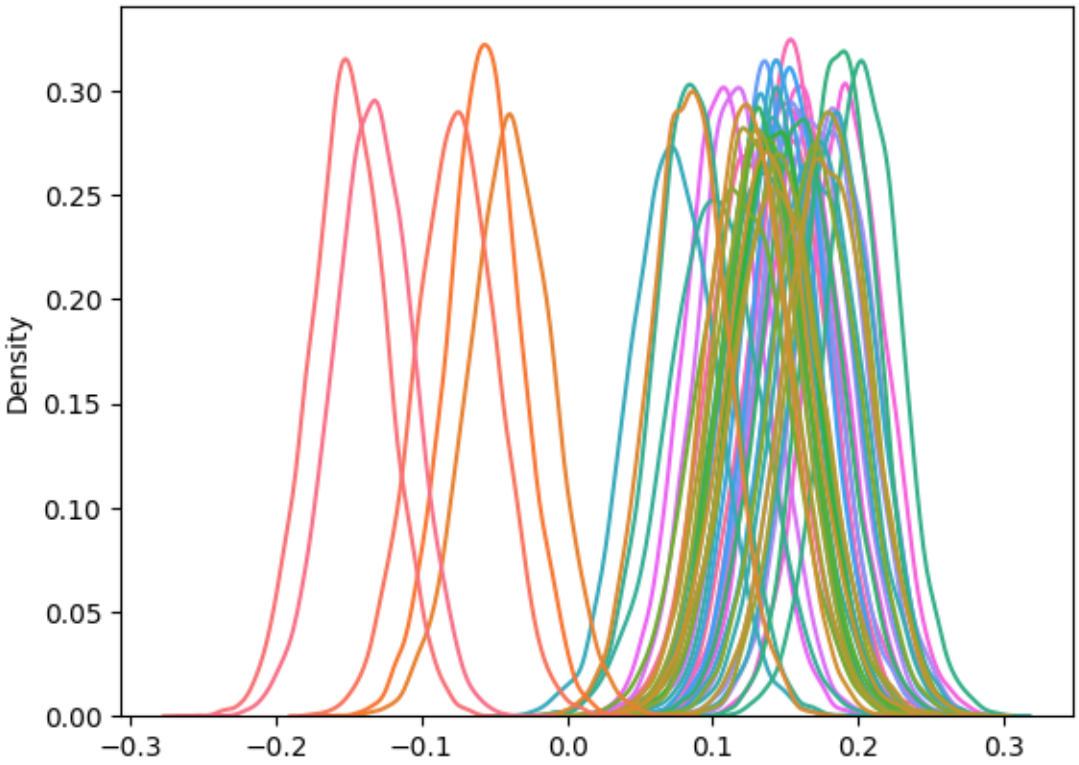

[15]:
```
aux_shape = ritorno['inference_data'].posterior.phi.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.phi.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2],aux_shape[3]))[:,1,:],␣
  ↪legend=False)
```

[15]:
```
<AxesSubplot: ylabel='Density'>
```



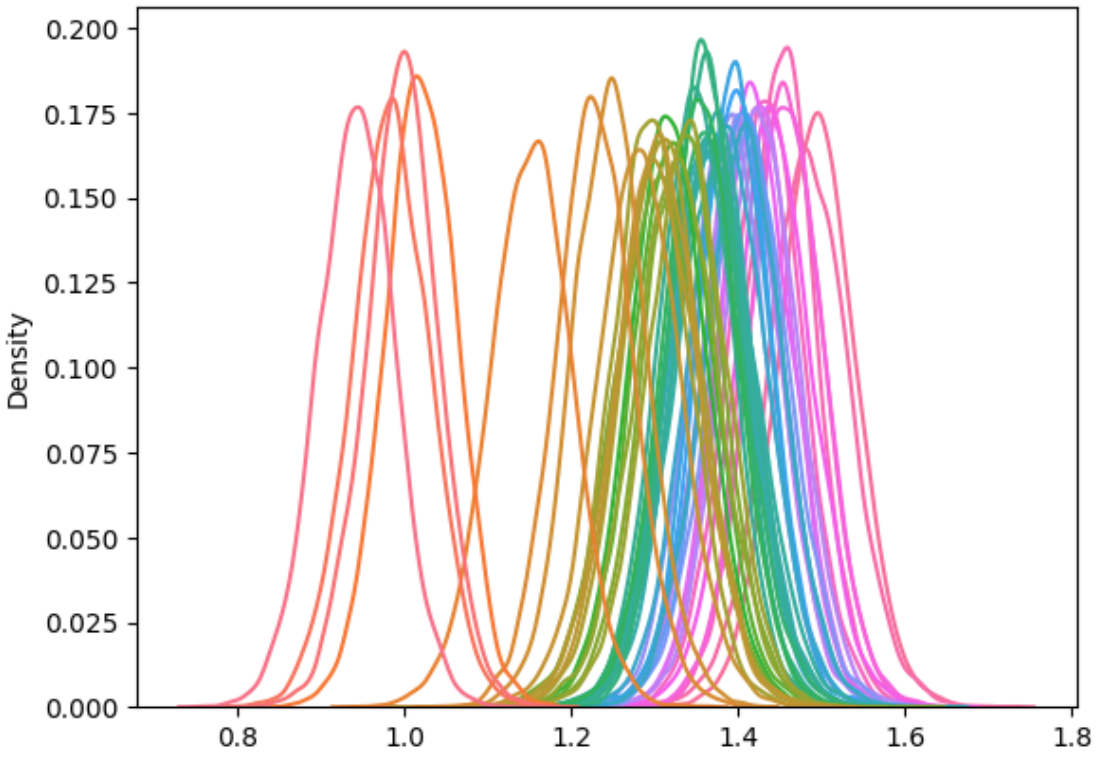

[16]:
```
aux_shape = ritorno['inference_data'].posterior.c.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.c.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

[16]: <AxesSubplot: ylabel='Density'>



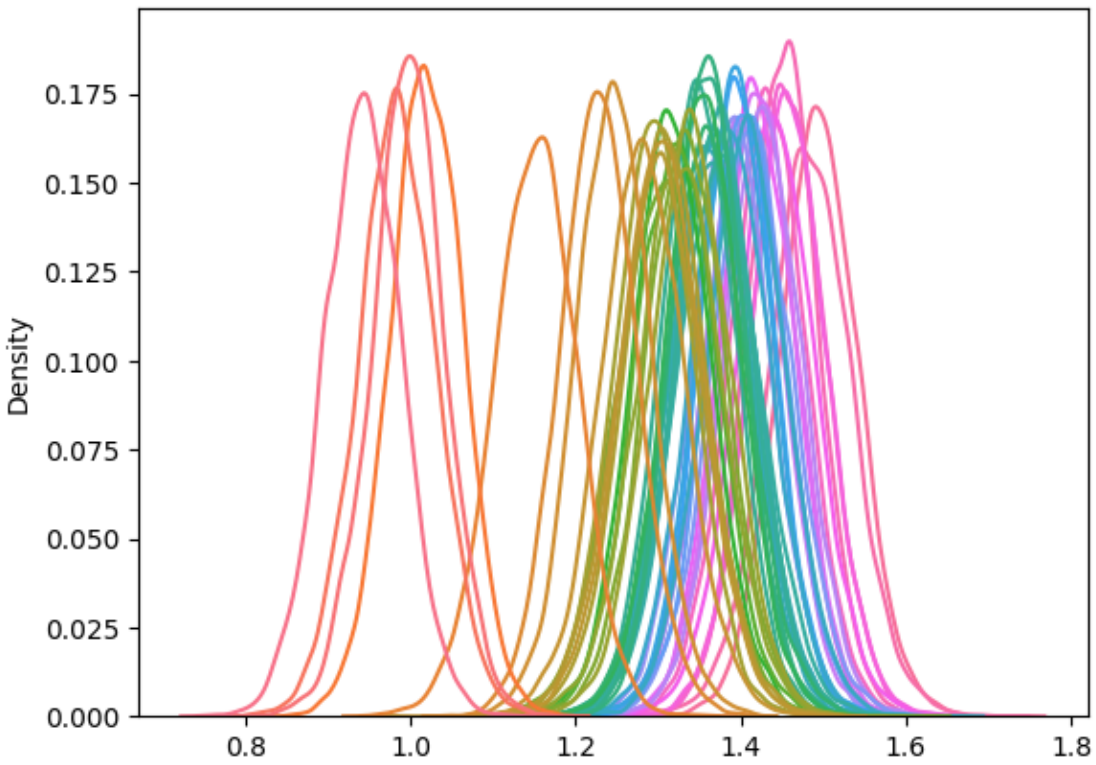

[17]:
```
aux_shape = ritorno['inference_data'].posterior.annual_mean.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_mean.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

[17]:
```
<AxesSubplot: ylabel='Density'>
```



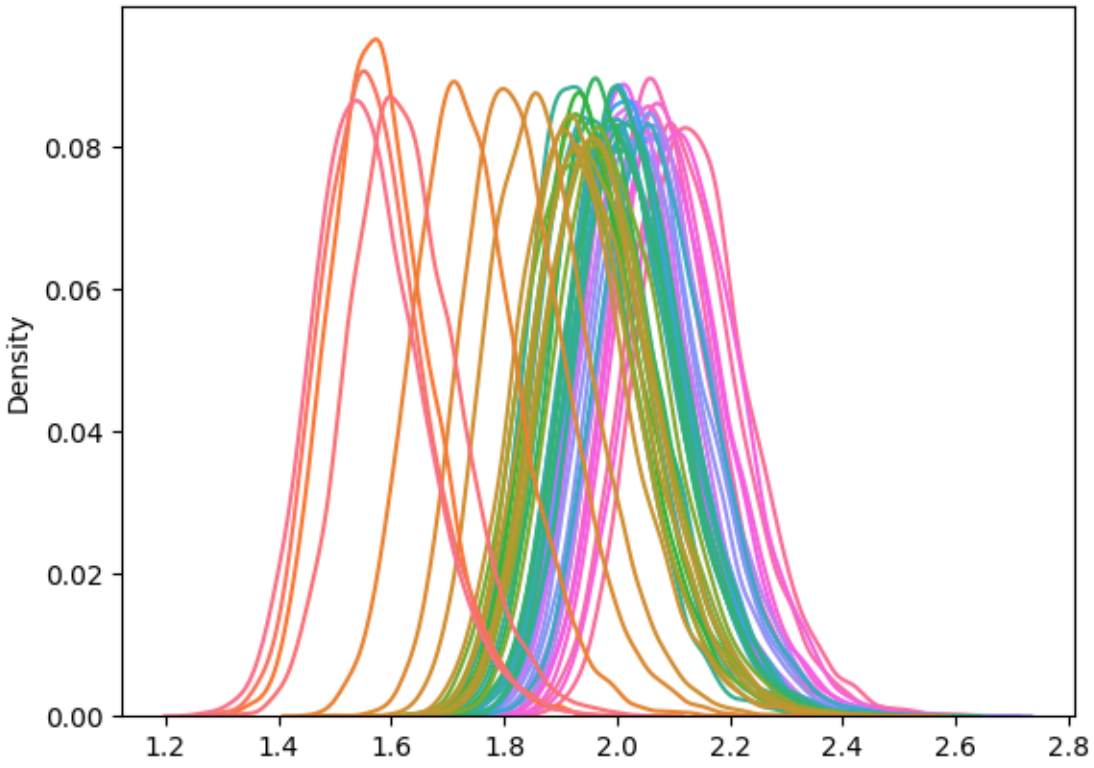

[18]:
```
aux_shape = ritorno['inference_data'].posterior.annual_median.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_median.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

[18]:
```
<AxesSubplot: ylabel='Density'>
```

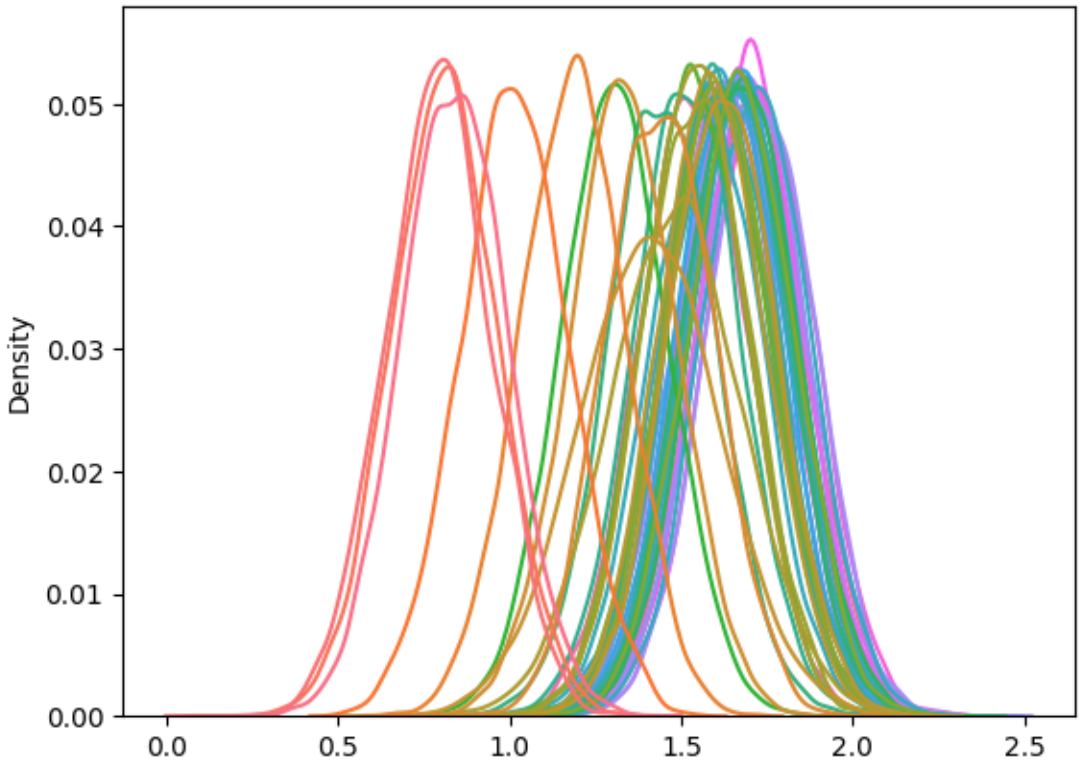



[19]:
```
aux_shape = ritorno['inference_data'].posterior.annual_max.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_max.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

[19]: <AxesSubplot: ylabel='Density'>

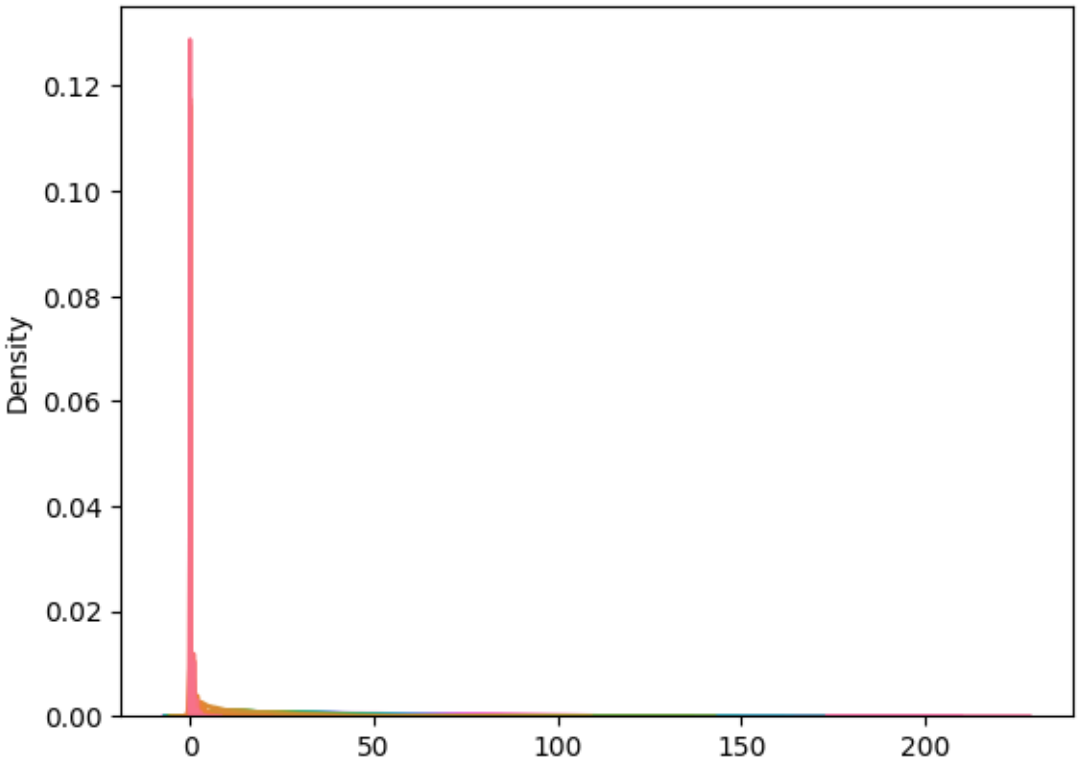



[20]:
```
valori_31_dic = []
for dizionario in ritorno['missing']:
    if dizionario['Data'] == '2018-12-31':
        valori_31_dic.append(dizionario['Samples'])

res_plot = sns.kdeplot(valori_31_dic, legend=False)
```




[21]:
```
aux_shape = ritorno['inference_data'].posterior.annual_days_over_threshold.
  ↪values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_days_over_threshold.
  ↪values.reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

[21]:
```
<AxesSubplot: ylabel='Density'>
```




[22]:
```
pd.set_option('display.max_columns', 500)
aux_results = pd.DataFrame(ritorno['inference_data'].posterior.
 ↪annual_days_over_threshold.values.
 ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), columns=df.columns).
 ↪describe()
aux_results.sort_values('mean', axis=1, ascending=True)
```

[22]:

| | CASTELLUCCIO | CORTE BRUGNATELLA | SAVIGNANO DI RIGO | FEBBIO | \ |
|---|---|---|---|---|---|
| count | 10000.00000 | 10000.000000 | 10000.000000 | 10000.000000 | |
| mean | 0.10200 | 0.115000 | 0.118500 | 0.302400 | |
| std | 0.36443 | 0.394703 | 0.398087 | 0.680147 | |
| min | 0.00000 | 0.000000 | 0.000000 | 0.000000 | |
| 25% | 0.00000 | 0.000000 | 0.000000 | 0.000000 | |
| 50% | 0.00000 | 0.000000 | 0.000000 | 0.000000 | |
| 75% | 0.00000 | 0.000000 | 0.000000 | 0.000000 | |
| max | 4.00000 | 7.000000 | 6.000000 | 8.000000 | |

| | SAN LEO | VERUCCHIO | BADIA | GIARDINI MARGHERITA | \ |
|---|---|---|---|---|---|
| count | 10000.000000 | 10000.000000 | 10000.000000 | 10000.000000 | |
| mean | 1.567600 | 4.877900 | 7.790400 | 13.415600 | |
| std | 1.962961 | 4.054311 | 5.462239 | 8.325383 | |
| min | 0.000000 | 0.000000 | 0.000000 | 0.000000 | |

```
25%        0.000000      2.000000      4.000000             7.000000
50%        1.000000      4.000000      7.000000            12.000000
75%        2.000000      7.000000     10.000000            18.000000
max       21.000000     38.000000     41.000000            80.000000

          MARECCHIA  SAN PIETRO CAPOFIUME  PARCO BERTOZZI  DELTA CERVIA  \
count  10000.000000          10000.000000    10000.000000  10000.000000
mean      15.608700             15.637100       17.239500     17.616200
std        9.067712              9.744521       10.226974      9.588717
min        0.000000              0.000000        0.000000      0.000000
25%        9.000000              9.000000       10.000000     11.000000
50%       14.000000             14.000000       15.000000     16.000000
75%       20.250000             21.000000       22.000000     23.000000
max       84.000000             92.000000       91.000000     83.000000

          LUGAGNANO     DE AMICIS   SAN LAZZARO  PARCO RESISTENZA  \
count  10000.000000  10000.000000  10000.000000      10000.000000
mean      17.707000     17.769500     18.701500         19.475400
std        9.695842      9.423346     10.193998         10.424829
min        0.000000      0.000000      0.000000          0.000000
25%       11.000000     11.000000     11.000000         12.000000
50%       16.000000     16.000000     17.000000         18.000000
75%       23.000000     23.000000     24.000000         25.000000
max       86.000000     85.000000     83.000000        104.000000

       FRANCHINI-ANGELONI      GHERARDI  VIA CHIARINI       GAVELLO  \
count        10000.000000  10000.000000  10000.000000  10000.000000
mean            21.104400     21.166500     21.361500     23.260100
std             11.205492     11.605751     11.138134     11.271324
min              0.000000      0.000000      0.000000      0.000000
25%             13.000000     13.000000     13.000000     15.000000
50%             19.000000     19.000000     20.000000     21.000000
75%             27.000000     27.000000     27.000000     30.000000
max            102.000000    112.000000     85.000000    101.000000

          SAVIGNANO     BESENZONE         ROMA  VILLA FULVIA  \
count  10000.000000  10000.000000  10000.00000  10000.000000
mean      23.932500     23.949300     28.18090     28.534400
std       11.896567     12.455571     13.45773     13.180083
min        0.000000      0.000000      1.00000      0.000000
25%       15.000000     15.000000     19.00000     19.000000
50%       22.000000     22.000000     26.00000     27.000000
75%       31.000000     31.000000     35.00000     36.000000
max      137.000000    105.000000    130.00000    166.000000

       PORTA SAN FELICE        CAORLE  CASTELLARANO         CENTO  \
count      10000.000000  10000.000000   10000.00000  10000.000000
```

| | | | | |
|---|---|---|---|---|
| mean | 28.738900 | 29.321800 | 29.62880 | 30.606900 |
| std | 13.040335 | 14.381499 | 12.01704 | 14.105356 |
| min | 0.000000 | 0.000000 | 2.00000 | 1.000000 |
| 25% | 19.000000 | 19.000000 | 21.00000 | 20.000000 |
| 50% | 27.000000 | 27.000000 | 28.00000 | 29.000000 |
| 75% | 36.000000 | 37.000000 | 37.00000 | 38.250000 |
| max | 101.000000 | 111.000000 | 98.00000 | 121.000000 |

| | ZALAMELLA | PARCO MONTECUCCO | PARCO EDILCARANI | BOGOLESE | \ |
|---|---|---|---|---|---|
| count | 10000.000000 | 10000.000000 | 10000.000000 | 10000.000000 | |
| mean | 30.616000 | 30.740400 | 31.929900 | 32.091500 | |
| std | 14.220372 | 14.289571 | 12.852171 | 13.487006 | |
| min | 1.000000 | 0.000000 | 2.000000 | 1.000000 | |
| 25% | 20.000000 | 20.000000 | 23.000000 | 22.000000 | |
| 50% | 28.000000 | 29.000000 | 30.000000 | 31.000000 | |
| 75% | 39.000000 | 39.000000 | 39.000000 | 40.000000 | |
| max | 119.000000 | 124.000000 | 100.000000 | 119.000000 | |

| | SARAGAT | PARADIGNA | MALCANTONE | S. LAZZARO | REMESINA | \ |
|---|---|---|---|---|---|---|
| count | 10000.000000 | 10000.000000 | 10000.00000 | 10000.00000 | 10000.00000 | |
| mean | 34.509200 | 35.694200 | 35.87640 | 36.64660 | 36.97600 | |
| std | 14.189815 | 15.221756 | 15.03205 | 15.35704 | 14.94129 | |
| min | 1.000000 | 2.000000 | 0.00000 | 2.00000 | 2.00000 | |
| 25% | 24.000000 | 25.000000 | 25.00000 | 26.00000 | 26.00000 | |
| 50% | 33.000000 | 34.000000 | 34.00000 | 35.00000 | 35.00000 | |
| 75% | 43.000000 | 44.000000 | 44.25000 | 45.00000 | 46.00000 | |
| max | 120.000000 | 130.000000 | 130.00000 | 144.00000 | 126.00000 | |

| | S. ROCCO | CENO | ISONZO | PARCO FERRARI | \ |
|---|---|---|---|---|---|
| count | 10000.000000 | 10000.000000 | 10000.000000 | 10000.000000 | |
| mean | 38.350700 | 41.990600 | 42.731600 | 42.800400 | |
| std | 15.436954 | 16.984556 | 16.497745 | 16.676348 | |
| min | 3.000000 | 4.000000 | 1.000000 | 1.000000 | |
| 25% | 27.000000 | 30.000000 | 31.000000 | 31.000000 | |
| 50% | 36.000000 | 40.000000 | 41.000000 | 41.000000 | |
| 75% | 47.000000 | 52.000000 | 52.000000 | 53.000000 | |
| max | 120.000000 | 153.000000 | 156.000000 | 141.000000 | |

| | GIORDANI-FARNESE | CITTADELLA | SAN FRANCESCO | FLAMINIA | \ |
|---|---|---|---|---|---|
| count | 10000.000000 | 10000.000000 | 10000.000000 | 10000.000000 | |
| mean | 46.467400 | 46.507200 | 50.969500 | 51.176500 | |
| std | 17.410958 | 17.140721 | 17.009283 | 18.785703 | |
| min | 4.000000 | 7.000000 | 9.000000 | 8.000000 | |
| 25% | 34.000000 | 34.000000 | 39.000000 | 38.000000 | |
| 50% | 45.000000 | 45.000000 | 50.000000 | 49.000000 | |
| 75% | 57.000000 | 57.000000 | 61.000000 | 62.000000 | |
| max | 155.000000 | 157.000000 | 139.000000 | 159.000000 | |

```
        MONTEBELLO      GIARDINI       GERBIDO        TIMAVO
count  10000.00000  10000.000000  10000.000000  10000.000000
mean      54.85700     60.543300     63.666400     70.191400
std       18.80313     19.254184     22.584466     21.885408
min        8.00000     10.000000      5.000000      9.000000
25%       41.00000     47.000000     48.000000     55.000000
50%       53.00000     59.000000     61.000000     69.000000
75%       66.00000     72.000000     77.000000     83.000000
max      156.00000    163.000000    199.000000    218.000000
```

[23]:
```
pd.set_option('display.max_columns', 500)
aux_results = pd.DataFrame(ritorno['inference_data'].posterior.
 ↪is_over_daily_limit.values.
 ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), columns=df.columns).
 ↪describe()
aux_results.sort_values('mean', axis=1, ascending=True)
```

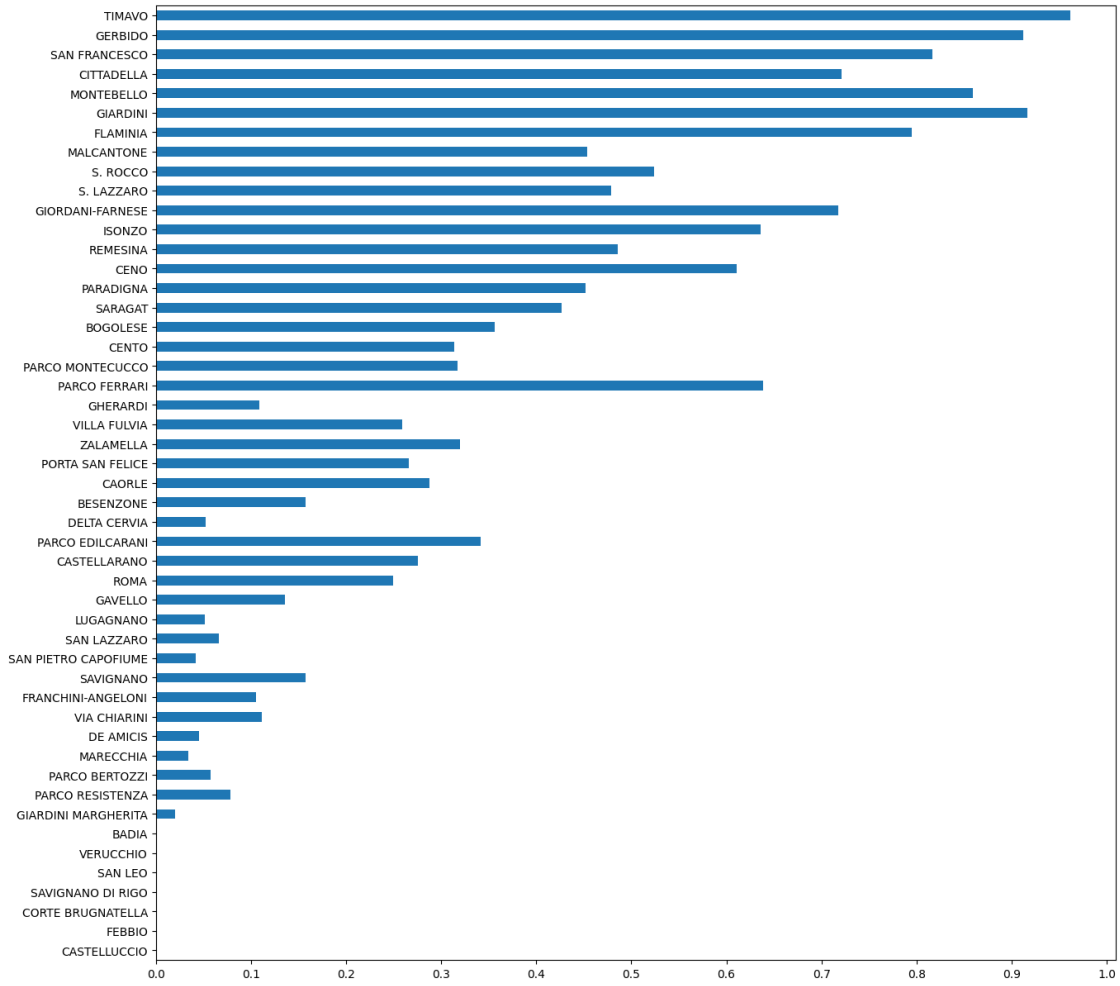
[23]:
```
       CASTELLUCCIO   FEBBIO  CORTE BRUGNATELLA  SAVIGNANO DI RIGO  SAN LEO  \
count       10000.0  10000.0            10000.0            10000.0  10000.0
mean            0.0      0.0                0.0                0.0      0.0
std             0.0      0.0                0.0                0.0      0.0
min             0.0      0.0                0.0                0.0      0.0
25%             0.0      0.0                0.0                0.0      0.0
50%             0.0      0.0                0.0                0.0      0.0
75%             0.0      0.0                0.0                0.0      0.0
max             0.0      0.0                0.0                0.0      0.0

          VERUCCHIO         BADIA  GIARDINI MARGHERITA     MARECCHIA  \
count  10000.000000  10000.000000         10000.000000  10000.000000
mean       0.000200      0.001300             0.019700      0.034300
std        0.014141      0.036034             0.138974      0.182008
min        0.000000      0.000000             0.000000      0.000000
25%        0.000000      0.000000             0.000000      0.000000
50%        0.000000      0.000000             0.000000      0.000000
75%        0.000000      0.000000             0.000000      0.000000
max        1.000000      1.000000             1.000000      1.000000

       SAN PIETRO CAPOFIUME     DE AMICIS     LUGAGNANO  DELTA CERVIA  \
count          10000.000000  10000.000000  10000.000000   10000.00000
mean               0.041900      0.045500      0.051700       0.05210
std                0.200371      0.208408      0.221432       0.22224
min                0.000000      0.000000      0.000000       0.00000
25%                0.000000      0.000000      0.000000       0.00000
50%                0.000000      0.000000      0.000000       0.00000
75%                0.000000      0.000000      0.000000       0.00000
max                1.000000      1.000000      1.000000       1.00000
```

```
       PARCO BERTOZZI   SAN LAZZARO  PARCO RESISTENZA  FRANCHINI-ANGELONI  \
count    10000.000000  10000.000000      10000.000000        10000.000000
mean         0.057100      0.066200          0.078100            0.105000
std          0.232045      0.248644          0.268342            0.306569
min          0.000000      0.000000          0.000000            0.000000
25%          0.000000      0.000000          0.000000            0.000000
50%          0.000000      0.000000          0.000000            0.000000
75%          0.000000      0.000000          0.000000            0.000000
max          1.000000      1.000000          1.000000            1.000000

           GHERARDI  VIA CHIARINI       GAVELLO     SAVIGNANO     BESENZONE  \
count  10000.000000  10000.000000  10000.000000  10000.000000  10000.000000
mean       0.108900      0.111100      0.135500      0.157300      0.157400
std        0.311529      0.314272      0.342274      0.364102      0.364196
min        0.000000      0.000000      0.000000      0.000000      0.000000
25%        0.000000      0.000000      0.000000      0.000000      0.000000
50%        0.000000      0.000000      0.000000      0.000000      0.000000
75%        0.000000      0.000000      0.000000      0.000000      0.000000
max        1.000000      1.000000      1.000000      1.000000      1.000000

              ROMA  VILLA FULVIA  PORTA SAN FELICE  CASTELLARANO  \
count  10000.000000  10000.000000       10000.00000  10000.000000
mean       0.249100      0.258900           0.26580      0.275400
std        0.432513      0.438052           0.44178      0.446738
min        0.000000      0.000000           0.00000      0.000000
25%        0.000000      0.000000           0.00000      0.000000
50%        0.000000      0.000000           0.00000      0.000000
75%        0.000000      1.000000           1.00000      1.000000
max        1.000000      1.000000           1.00000      1.000000

            CAORLE         CENTO  PARCO MONTECUCCO     ZALAMELLA  \
count  10000.000000  10000.000000      10000.000000  10000.000000
mean       0.287700      0.313500          0.316800      0.319500
std        0.452713      0.463939          0.465252      0.466306
min        0.000000      0.000000          0.000000      0.000000
25%        0.000000      0.000000          0.000000      0.000000
50%        0.000000      0.000000          0.000000      0.000000
75%        1.000000      1.000000          1.000000      1.000000
max        1.000000      1.000000          1.000000      1.000000

       PARCO EDILCARANI      BOGOLESE       SARAGAT     PARADIGNA  \
count       10000.00000  10000.000000  10000.000000  10000.000000
mean            0.34190      0.356600      0.426600      0.452100
std             0.47437      0.479019      0.494608      0.497725
min             0.00000      0.000000      0.000000      0.000000
25%             0.00000      0.000000      0.000000      0.000000
```

```
50%             0.00000      0.000000      0.000000      0.000000
75%             1.00000      1.000000      1.000000      1.000000
max             1.00000      1.000000      1.000000      1.000000

         MALCANTONE   S. LAZZARO      REMESINA      S. ROCCO          CENO  \
count  10000.000000  10000.00000  10000.000000  10000.000000  10000.000000
mean       0.453500      0.47890      0.485400      0.524300      0.610400
std        0.497858      0.49958      0.499812      0.499434      0.487684
min        0.000000      0.00000      0.000000      0.000000      0.000000
25%        0.000000      0.00000      0.000000      0.000000      0.000000
50%        0.000000      0.00000      0.000000      1.000000      1.000000
75%        1.000000      1.00000      1.000000      1.000000      1.000000
max        1.000000      1.00000      1.000000      1.000000      1.000000

             ISONZO  PARCO FERRARI  GIORDANI-FARNESE    CITTADELLA  \
count  10000.000000   10000.000000      10000.000000  10000.000000
mean       0.635600       0.638300          0.717900      0.721100
std        0.481286       0.480517          0.450044      0.448481
min        0.000000       0.000000          0.000000      0.000000
25%        0.000000       0.000000          0.000000      0.000000
50%        1.000000       1.000000          1.000000      1.000000
75%        1.000000       1.000000          1.000000      1.000000
max        1.000000       1.000000          1.000000      1.000000

             FLAMINIA  SAN FRANCESCO    MONTEBELLO       GERBIDO      GIARDINI  \
count  10000.000000   10000.000000  10000.000000  10000.000000  10000.000000
mean       0.794600       0.816300      0.858800      0.912300      0.916200
std        0.404014       0.387259      0.348245      0.282872      0.277101
min        0.000000       0.000000      0.000000      0.000000      0.000000
25%        1.000000       1.000000      1.000000      1.000000      1.000000
50%        1.000000       1.000000      1.000000      1.000000      1.000000
75%        1.000000       1.000000      1.000000      1.000000      1.000000
max        1.000000       1.000000      1.000000      1.000000      1.000000

             TIMAVO
count  10000.000000
mean       0.961700
std        0.191929
min        0.000000
25%        1.000000
50%        1.000000
75%        1.000000
max        1.000000
```

[24]:
```
aux_results.loc['mean',:].plot(kind='barh', figsize=(15,15), xticks=np.
 ↪linspace(0,1,11))
#res = plt.xticks(rotation = 30)
```

[24]: <AxesSubplot: >




[25]:
```
pd.set_option('display.max_columns', 500)
aux_results = pd.DataFrame(ritorno['inference_data'].posterior.
 ↪is_over_annual_limit.values.
 ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), columns=df.columns).
 ↪describe()
aux_results.sort_values('mean', axis=1, ascending=True)
```

[25]:

| | CASTELLUCCIO | ROMA | CASTELLARANO | PARCO EDILCARANI | DELTA CERVIA | \ |
|---|---|---|---|---|---|---|
| count | 10000.0 | 10000.0 | 10000.0 | 10000.0 | 10000.0 | |
| mean | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| std | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| min | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 25% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 50% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |
| 75% | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | |

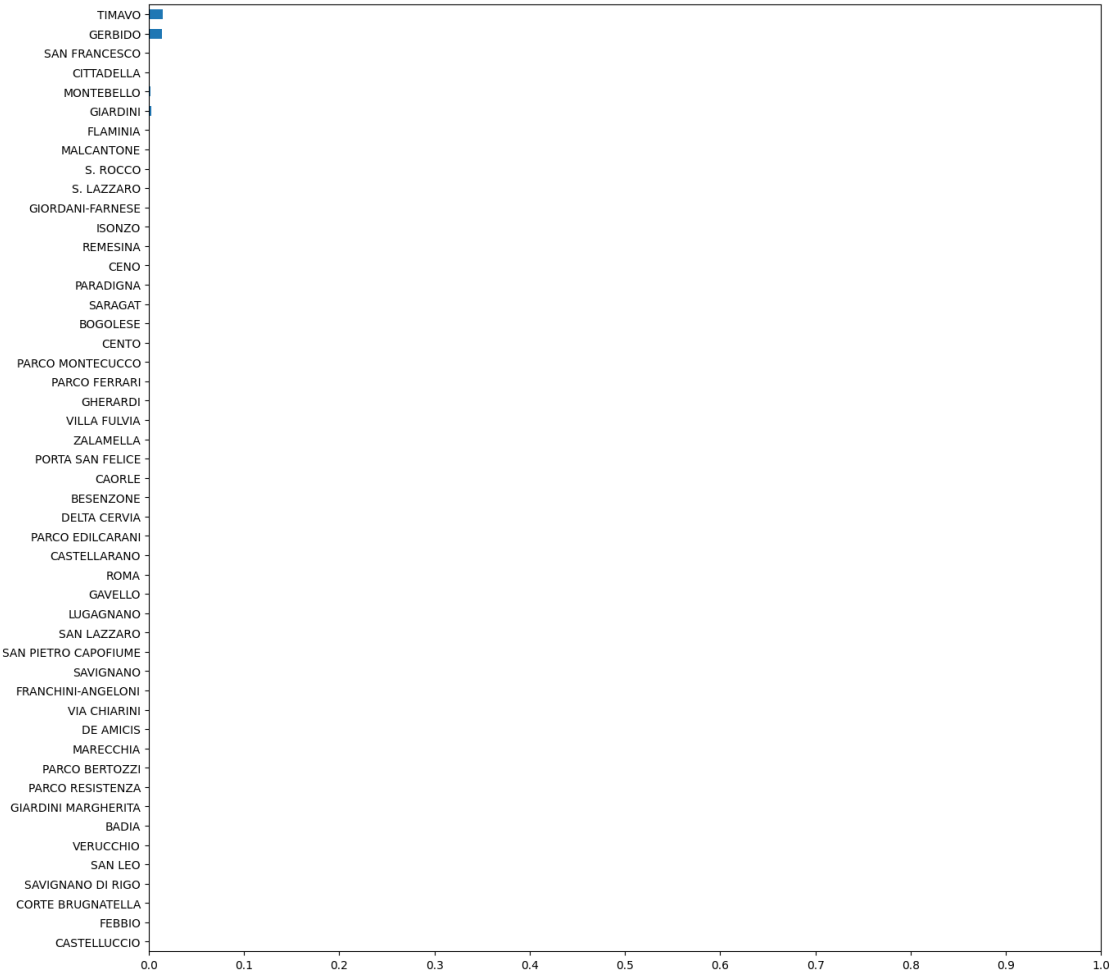
```
max             0.0      0.0           0.0               0.0           0.0

       BESENZONE  PORTA SAN FELICE  GAVELLO  ZALAMELLA  PARCO MONTECUCCO  \
count    10000.0           10000.0  10000.0    10000.0           10000.0
mean         0.0               0.0      0.0        0.0               0.0
std          0.0               0.0      0.0        0.0               0.0
min          0.0               0.0      0.0        0.0               0.0
25%          0.0               0.0      0.0        0.0               0.0
50%          0.0               0.0      0.0        0.0               0.0
75%          0.0               0.0      0.0        0.0               0.0
max          0.0               0.0      0.0        0.0               0.0

         CENTO  BOGOLESE  SARAGAT  REMESINA  S. ROCCO  GHERARDI  LUGAGNANO  \
count  10000.0   10000.0  10000.0   10000.0   10000.0   10000.0    10000.0
mean       0.0       0.0      0.0       0.0       0.0       0.0        0.0
std        0.0       0.0      0.0       0.0       0.0       0.0        0.0
min        0.0       0.0      0.0       0.0       0.0       0.0        0.0
25%        0.0       0.0      0.0       0.0       0.0       0.0        0.0
50%        0.0       0.0      0.0       0.0       0.0       0.0        0.0
75%        0.0       0.0      0.0       0.0       0.0       0.0        0.0
max        0.0       0.0      0.0       0.0       0.0       0.0        0.0

        CAORLE  SAN PIETRO CAPOFIUME   FEBBIO  CORTE BRUGNATELLA  SAN LAZZARO  \
count  10000.0               10000.0  10000.0            10000.0      10000.0
mean       0.0                   0.0      0.0                0.0          0.0
std        0.0                   0.0      0.0                0.0          0.0
min        0.0                   0.0      0.0                0.0          0.0
25%        0.0                   0.0      0.0                0.0          0.0
50%        0.0                   0.0      0.0                0.0          0.0
75%        0.0                   0.0      0.0                0.0          0.0
max        0.0                   0.0      0.0                0.0          0.0

       SAN LEO  VERUCCHIO    BADIA  GIARDINI MARGHERITA  SAVIGNANO DI RIGO  \
count  10000.0    10000.0  10000.0              10000.0            10000.0
mean       0.0        0.0      0.0                 0.0                0.0
std        0.0        0.0      0.0                 0.0                0.0
min        0.0        0.0      0.0                 0.0                0.0
25%        0.0        0.0      0.0                 0.0                0.0
50%        0.0        0.0      0.0                 0.0                0.0
75%        0.0        0.0      0.0                 0.0                0.0
max        0.0        0.0      0.0                 0.0                0.0

       PARCO BERTOZZI  MARECCHIA  DE AMICIS  VIA CHIARINI  FRANCHINI-ANGELONI  \
count         10000.0    10000.0    10000.0       10000.0             10000.0
mean              0.0        0.0        0.0           0.0                 0.0
std               0.0        0.0        0.0           0.0                 0.0
min               0.0        0.0        0.0           0.0                 0.0
```

```
25%              0.0        0.0        0.0           0.0                 0.0
50%              0.0        0.0        0.0           0.0                 0.0
75%              0.0        0.0        0.0           0.0                 0.0
max              0.0        0.0        0.0           0.0                 0.0

       PARCO RESISTENZA  VILLA FULVIA  MALCANTONE   SAVIGNANO  S. LAZZARO  \
count           10000.0    10000.0000  10000.0000  10000.0000  10000.0000
mean                0.0        0.0001      0.0001      0.0001      0.0001
std                 0.0        0.0100      0.0100      0.0100      0.0100
min                 0.0        0.0000      0.0000      0.0000      0.0000
25%                 0.0        0.0000      0.0000      0.0000      0.0000
50%                 0.0        0.0000      0.0000      0.0000      0.0000
75%                 0.0        0.0000      0.0000      0.0000      0.0000
max                 0.0        1.0000      1.0000      1.0000      1.0000

             CENO        ISONZO     PARADIGNA  SAN FRANCESCO  PARCO FERRARI  \
count  10000.0000  10000.000000  10000.000000   10000.000000   10000.000000
mean       0.0001      0.000200      0.000200       0.000300       0.000400
std        0.0100      0.014141      0.014141       0.017319       0.019997
min        0.0000      0.000000      0.000000       0.000000       0.000000
25%        0.0000      0.000000      0.000000       0.000000       0.000000
50%        0.0000      0.000000      0.000000       0.000000       0.000000
75%        0.0000      0.000000      0.000000       0.000000       0.000000
max        1.0000      1.000000      1.000000       1.000000       1.000000

       GIORDANI-FARNESE    CITTADELLA      FLAMINIA    MONTEBELLO  \
count      10000.000000  10000.000000  10000.000000  10000.000000
mean           0.000400      0.000600      0.001400      0.001700
std            0.019997      0.024489      0.037392      0.041198
min            0.000000      0.000000      0.000000      0.000000
25%            0.000000      0.000000      0.000000      0.000000
50%            0.000000      0.000000      0.000000      0.000000
75%            0.000000      0.000000      0.000000      0.000000
max            1.000000      1.000000      1.000000      1.000000

           GIARDINI       GERBIDO        TIMAVO
count  10000.000000  10000.000000  10000.000000
mean       0.002400      0.014100      0.014600
std        0.048933      0.117909      0.119951
min        0.000000      0.000000      0.000000
25%        0.000000      0.000000      0.000000
50%        0.000000      0.000000      0.000000
75%        0.000000      0.000000      0.000000
max        1.000000      1.000000      1.000000
```

[26]:
```
aux_results.loc['mean',:].plot(kind='barh', figsize=(15,15), xticks=np.
 ↪linspace(0,1,11))
```

```
#res = plt.xticks(rotation = 30)
```

[26]: <AxesSubplot: >




[27]:
```
y_post_pred = ritorno['inference_data'].posterior.y_post_pred.to_numpy()
y_post_pred = y_post_pred.reshape(y_post_pred.shape[0]*y_post_pred.shape[1],␣
  ↪y_post_pred.shape[2], y_post_pred.shape[3])
y_post_pred.shape
```

[27]: (10000, 365, 49)

[28]:
```
import ipywidgets as widgets
from ipywidgets import HBox, VBox
from IPython.display import display
```

[29]:
```
@widgets.interact(stazione = df.columns)
def f(stazione):
    col_map = sns.light_palette((20, 75, 70), input='husl', as_cmap=True)

    plt.figure(figsize=(14,8))
    ax = plt.subplot(1,1,1)

    idx_stazione = df.columns.to_list().index(stazione)

    """
    sns.lineplot(np.transpose(y_post_pred[0:50,:,idx_stazione]))
    """

    lower_lim = np.zeros(len(df.index))
    upper_lim = np.zeros(len(df.index))
    for i in range(len(df.index)):
        lower_lim[i] = np.percentile(y_post_pred[:,i,idx_stazione],2.5)
        upper_lim[i] = np.percentile(y_post_pred[:,i,idx_stazione],97.5)


#    sns.lineplot(lower_lim)
#    sns.lineplot(upper_lim)

    for i in range(len(df.index)):
        ax.add_patch(mplt.patches.
 ↪Rectangle((i,lower_lim[i]),1,upper_lim[i]-lower_lim[i], fill=True,␣
 ↪color=col_map(180)))

    sns.lineplot(df[stazione])
    sns.lineplot(np.mean(y_post_pred[:,:,idx_stazione], axis=0))


    index = 0
    for line in ax.get_lines():
        if index == 0:
            col_map = sns.dark_palette((230,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(155))
        else:
            col_map = sns.dark_palette((10,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(175))
        index += 1

    plt.ylim(bottom=0,top=2.5)

    primo_giorno = datetime.date(2018,1,1)
    date_da_segnare = []
    date_da_segnare_posizioni = []
```

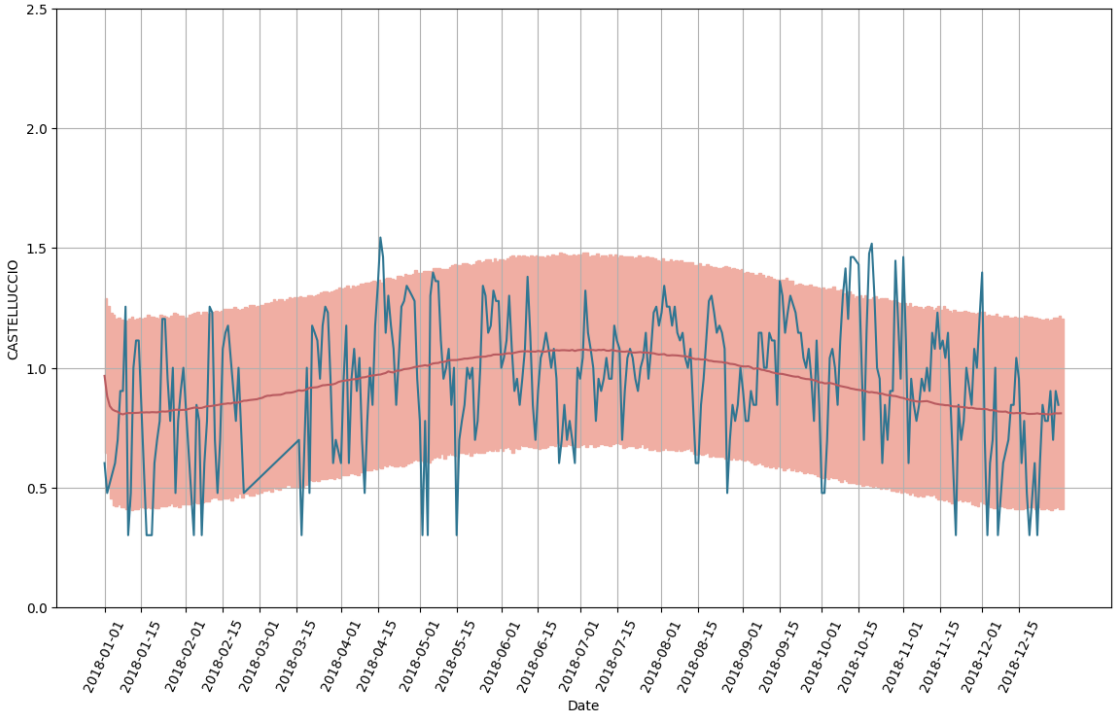
```
    for i in range(12):
        date_da_segnare.append(datetime.date(2018,i+1,1))
        date_da_segnare_posizioni.append((date_da_segnare[2*i] - primo_giorno).
↪days)
        date_da_segnare.append(datetime.date(2018,i+1,15))
        date_da_segnare_posizioni.append((date_da_segnare[2*i+1] -␣
↪primo_giorno).days)
        date_da_segnare[2*i] = date_da_segnare[2*i].isoformat()
        date_da_segnare[2*i+1] = date_da_segnare[2*i+1].isoformat()

    plt.xticks(date_da_segnare_posizioni,date_da_segnare,rotation=65)
    plt.tick_params(
        axis='x',          # changes apply to the x-axis
        which='both',      # both major and minor ticks are affected
        bottom=True,      # ticks along the bottom edge are off
        top=False,         # ticks along the top edge are off
        labelbottom=True)
    plt.grid()

    """
    ax.get_legend().remove()
    col_vals = np.linspace(1,255,num=len(df.columns))
    index = 0
    for line in ax.get_lines():
        if(index == len(ax.get_lines()) - 1):
            col_map = sns.dark_palette((230,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(175))
            continue
        if(index == len(ax.get_lines()) - 2):
            col_map = sns.dark_palette((120,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(175))
            index += 1
            continue

        #line.set_c(col_map(int(np.round(col_vals[index]))))
        line.set_c(col_map(220))
        line.set_alpha(0.3)
        index += 1
    """



    plt.show()
```

```
interactive(children=(Dropdown(description='stazione', options=('CASTELLUCCIO',␣
↪'FEBBIO', 'CORTE BRUGNATELLA',…
```

[30]:
```
def f(stazione):
    col_map = sns.light_palette((20, 75, 70), input='husl', as_cmap=True)

    plt.figure(figsize=(14,8))
    ax = plt.subplot(1,1,1)

    idx_stazione = df.columns.to_list().index(stazione)

    """
    sns.lineplot(np.transpose(y_post_pred[0:50,:,idx_stazione]))
    """

    lower_lim = np.zeros(len(df.index))
    upper_lim = np.zeros(len(df.index))
    for i in range(len(df.index)):
        lower_lim[i] = np.percentile(y_post_pred[:,i,idx_stazione],2.5)
        upper_lim[i] = np.percentile(y_post_pred[:,i,idx_stazione],97.5)


#    sns.lineplot(lower_lim)
#    sns.lineplot(upper_lim)

    for i in range(len(df.index)):
        ax.add_patch(mplt.patches.
 ↪Rectangle((i,lower_lim[i]),1,upper_lim[i]-lower_lim[i], fill=True,␣
 ↪color=col_map(180)))

    sns.lineplot(df[stazione])
    sns.lineplot(np.mean(y_post_pred[:,:,idx_stazione], axis=0))


    index = 0
    for line in ax.get_lines():
        if index == 0:
            col_map = sns.dark_palette((230,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(155))
        else:
            col_map = sns.dark_palette((10,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(175))
        index += 1

    plt.ylim(bottom=0,top=2.5)

    primo_giorno = datetime.date(2018,1,1)
    date_da_segnare = []
    date_da_segnare_posizioni = []
```

```
    for i in range(12):
        date_da_segnare.append(datetime.date(2018,i+1,1))
        date_da_segnare_posizioni.append((date_da_segnare[2*i] - primo_giorno).
↪days)
        date_da_segnare.append(datetime.date(2018,i+1,15))
        date_da_segnare_posizioni.append((date_da_segnare[2*i+1] -␣
↪primo_giorno).days)
        date_da_segnare[2*i] = date_da_segnare[2*i].isoformat()
        date_da_segnare[2*i+1] = date_da_segnare[2*i+1].isoformat()

    plt.xticks(date_da_segnare_posizioni,date_da_segnare,rotation=65)
    plt.tick_params(
        axis='x',          # changes apply to the x-axis
        which='both',      # both major and minor ticks are affected
        bottom=True,      # ticks along the bottom edge are off
        top=False,         # ticks along the top edge are off
        labelbottom=True)
    plt.grid()

    """
    ax.get_legend().remove()
    col_vals = np.linspace(1,255,num=len(df.columns))
    index = 0
    for line in ax.get_lines():
        if(index == len(ax.get_lines()) - 1):
            col_map = sns.dark_palette((230,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(175))
            continue
        if(index == len(ax.get_lines()) - 2):
            col_map = sns.dark_palette((120,90,65), input='husl', as_cmap=True)
            line.set_c(col_map(175))
            index += 1
            continue

        #line.set_c(col_map(int(np.round(col_vals[index]))))
        line.set_c(col_map(220))
        line.set_alpha(0.3)
        index += 1
    """



    plt.show()
```

[31]:
```
for stazione in df.columns:
    f(stazione)
```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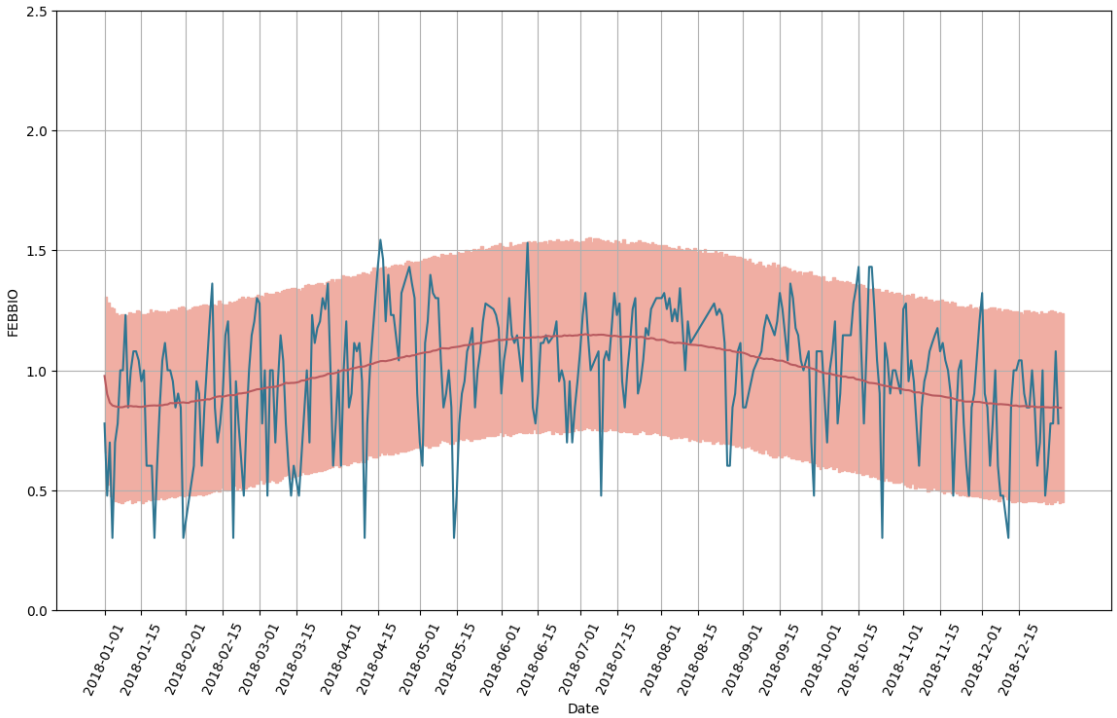
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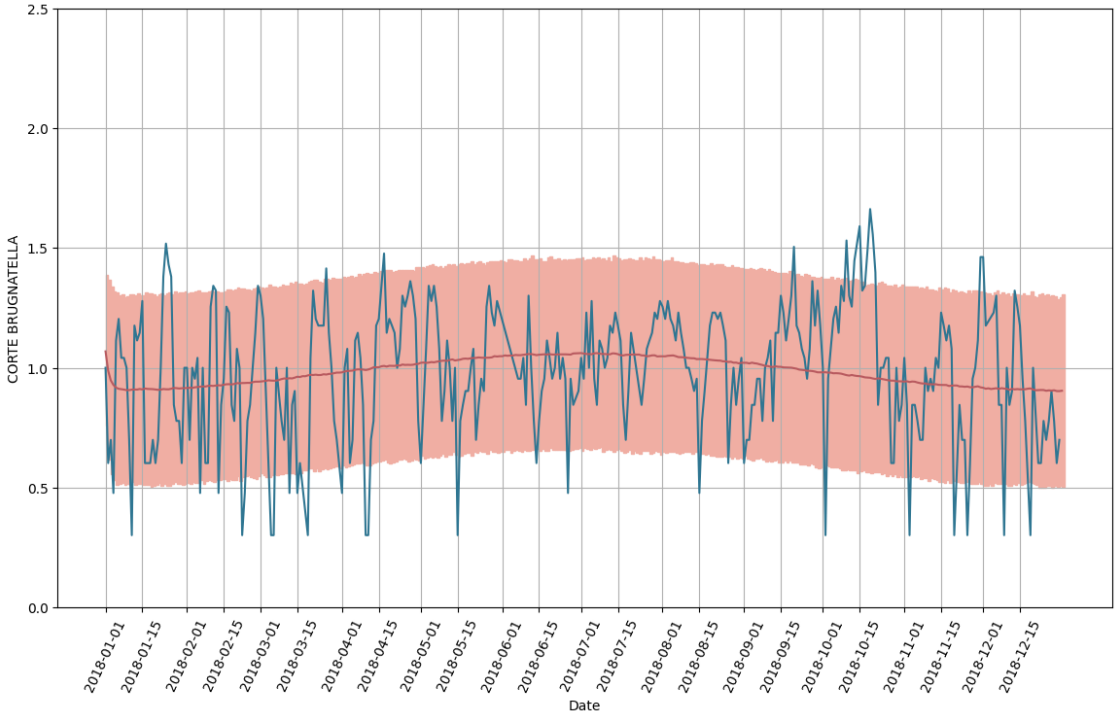
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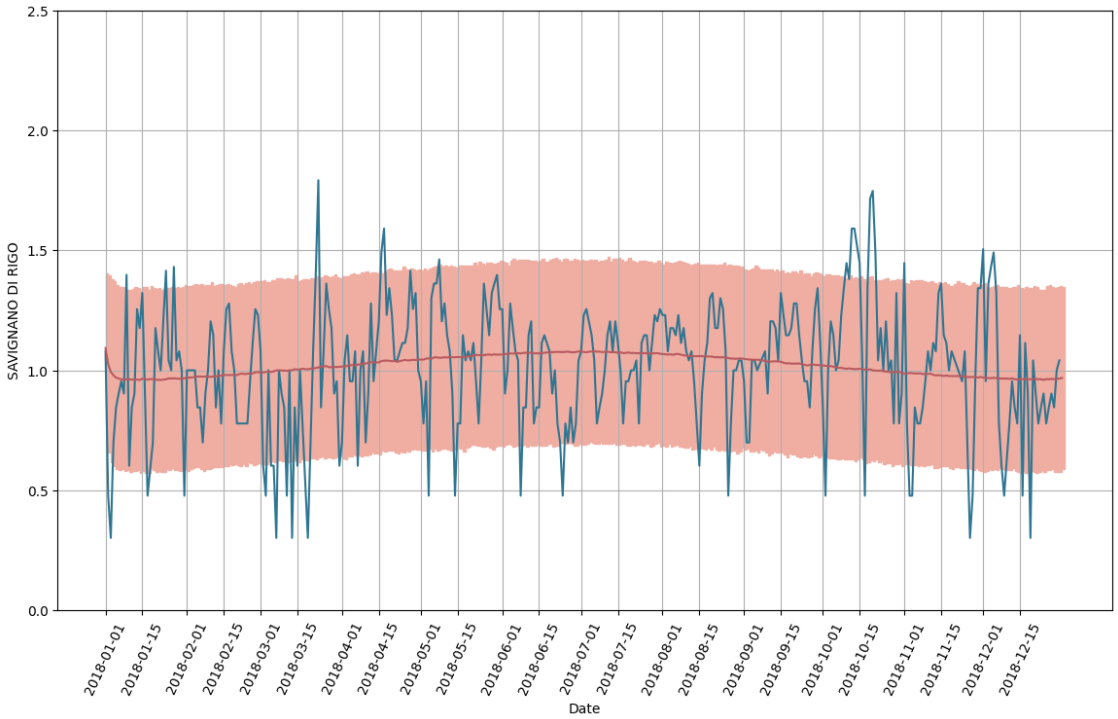
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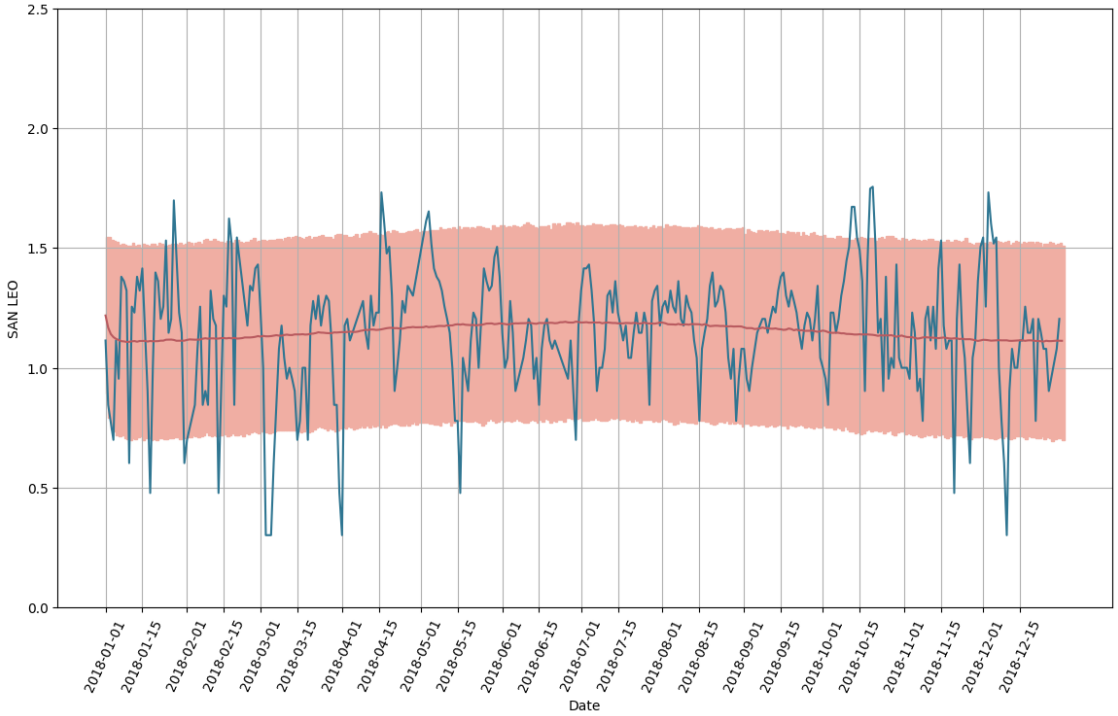
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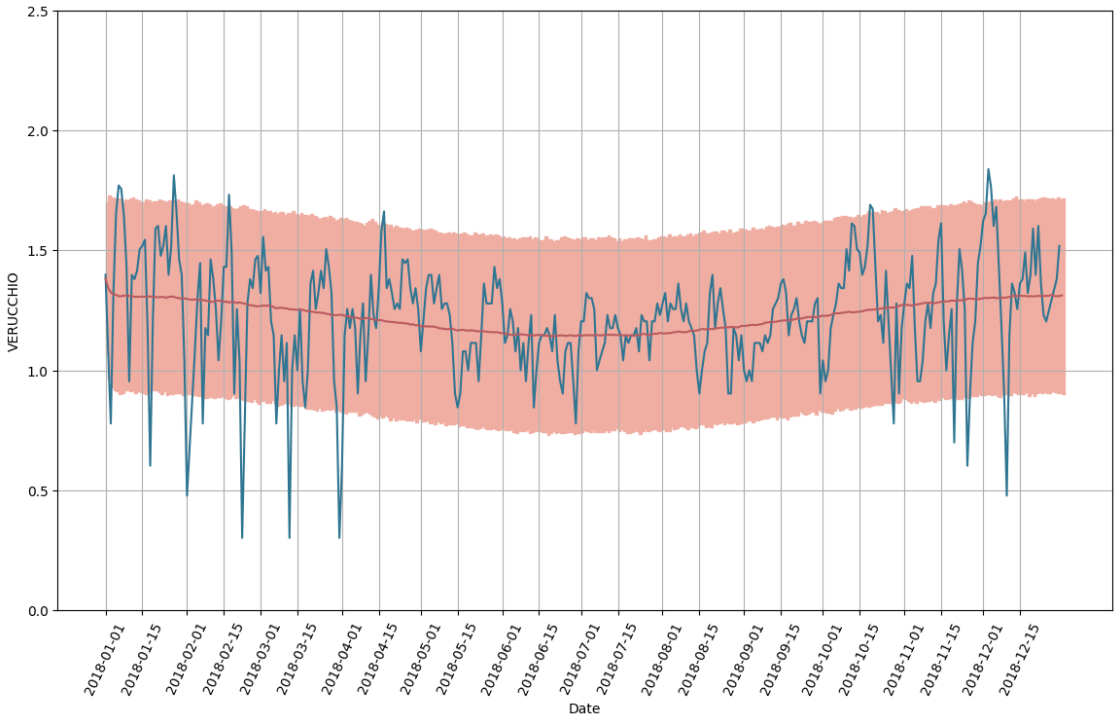
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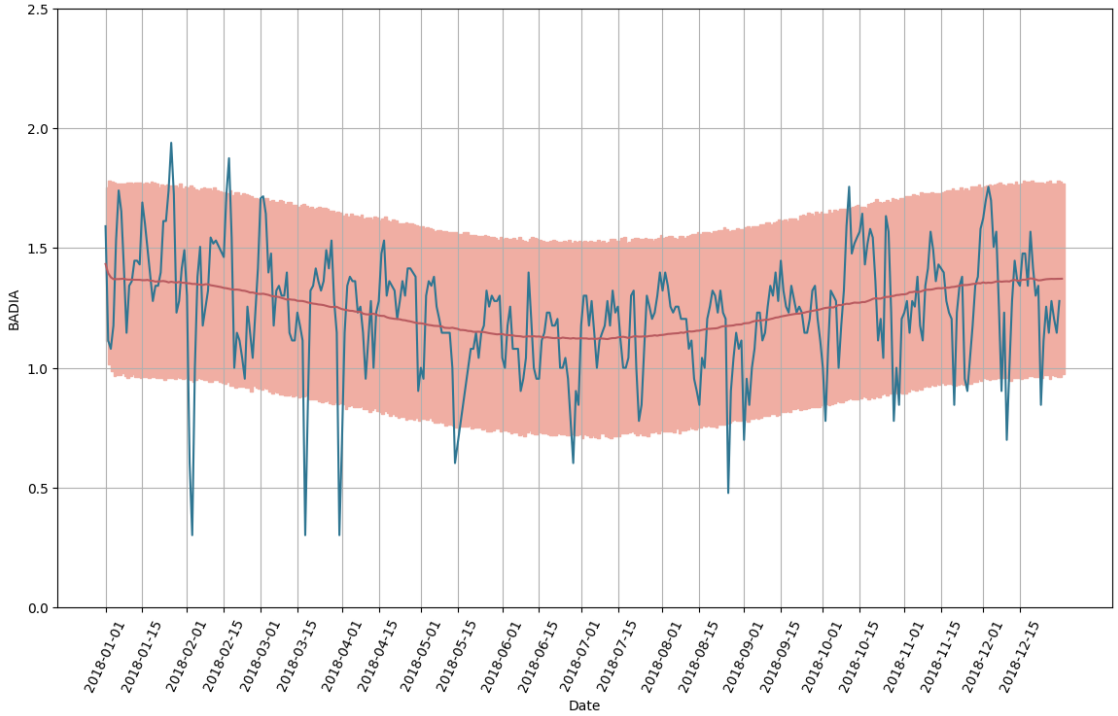
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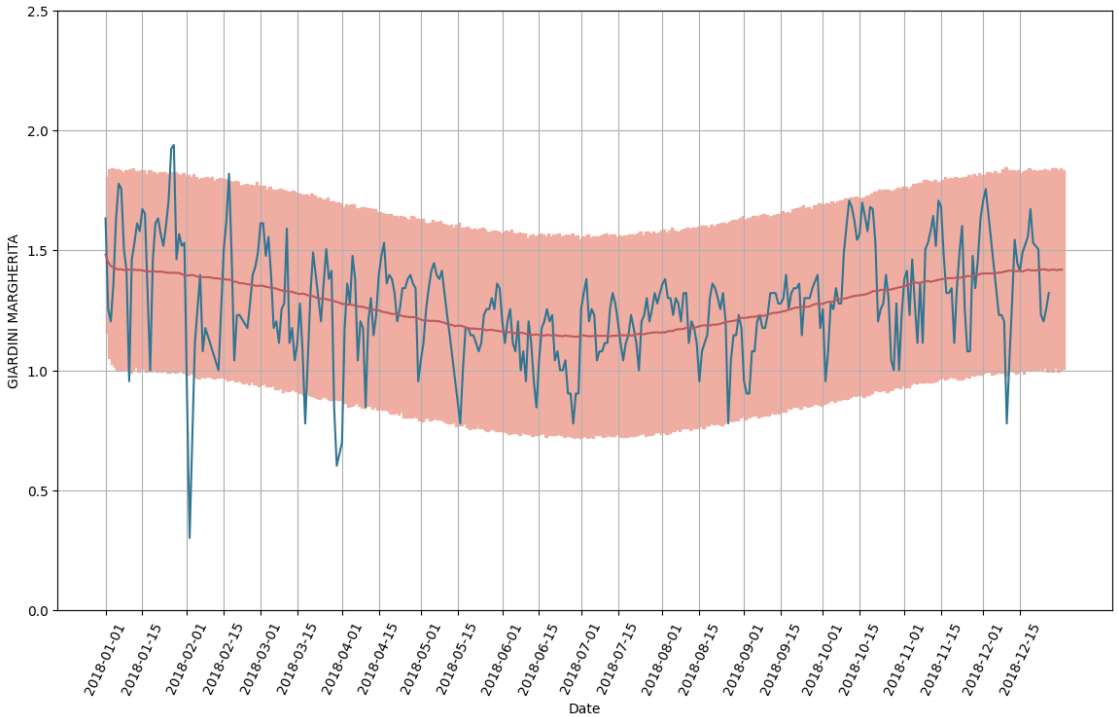
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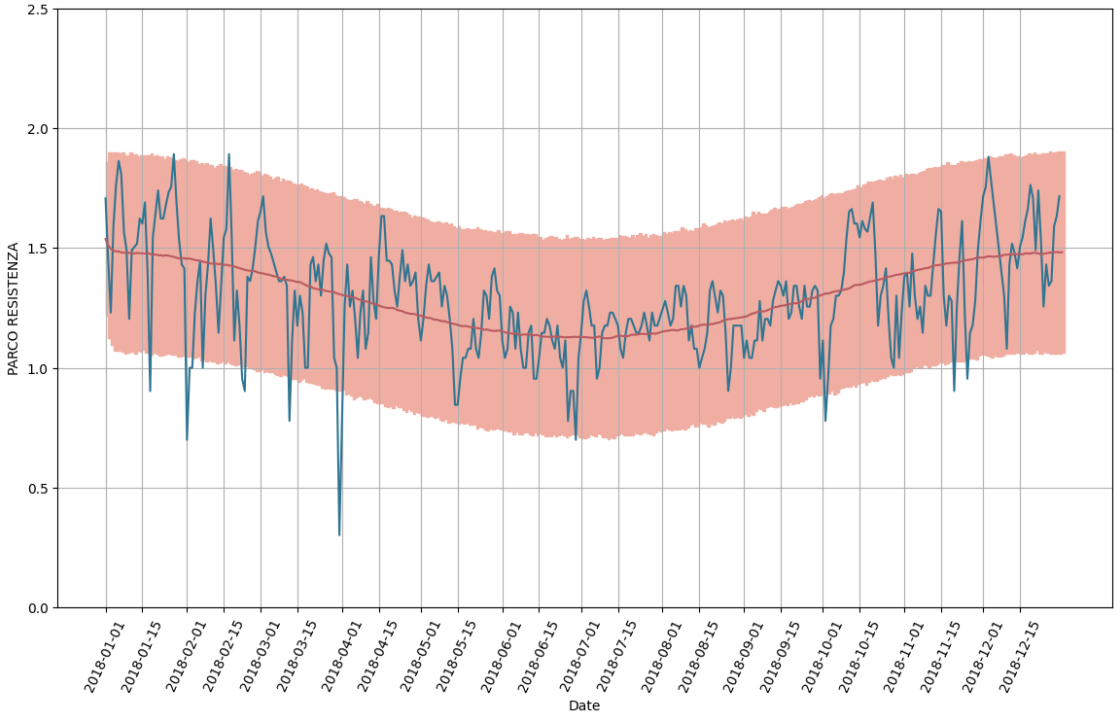
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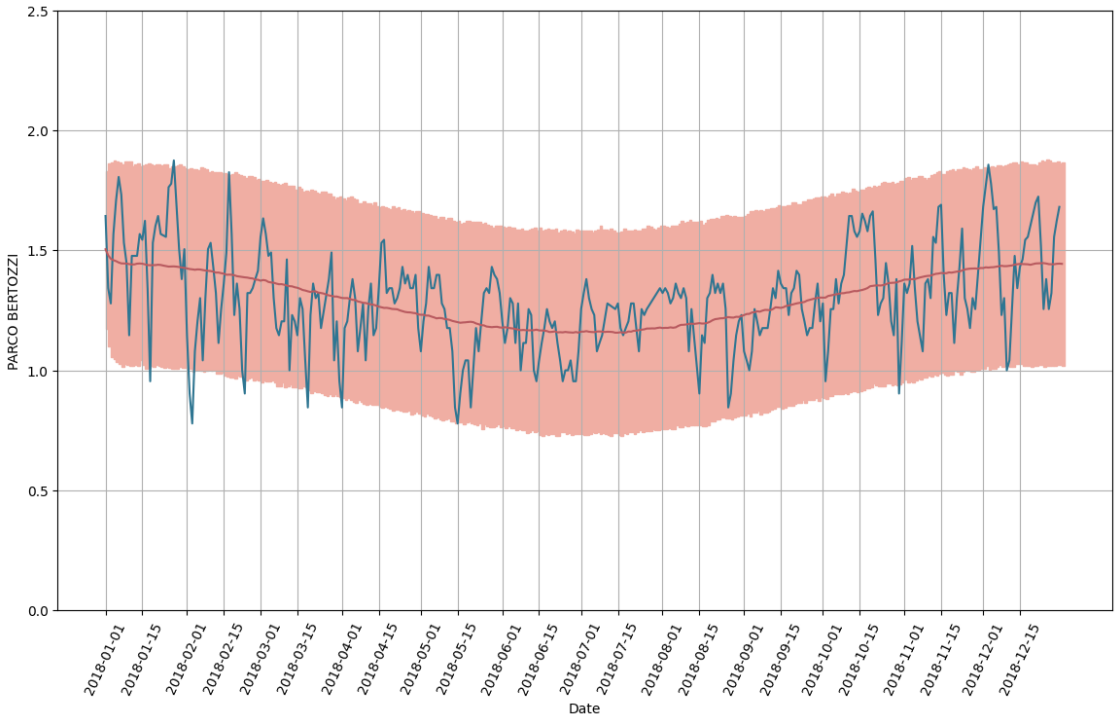
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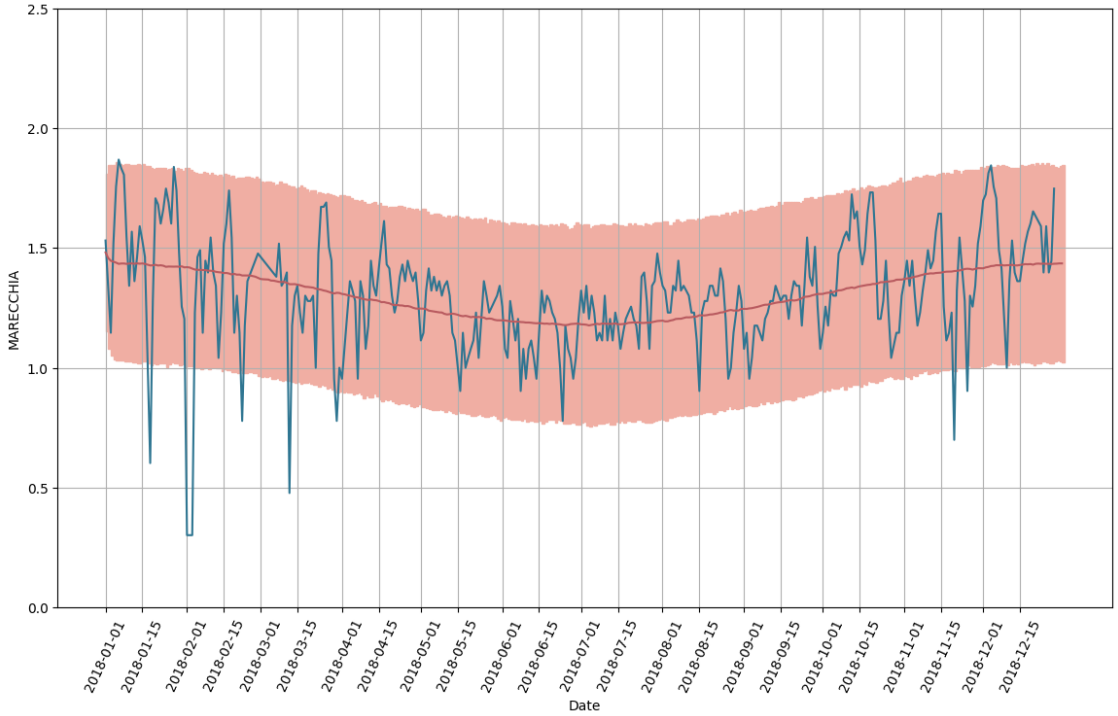
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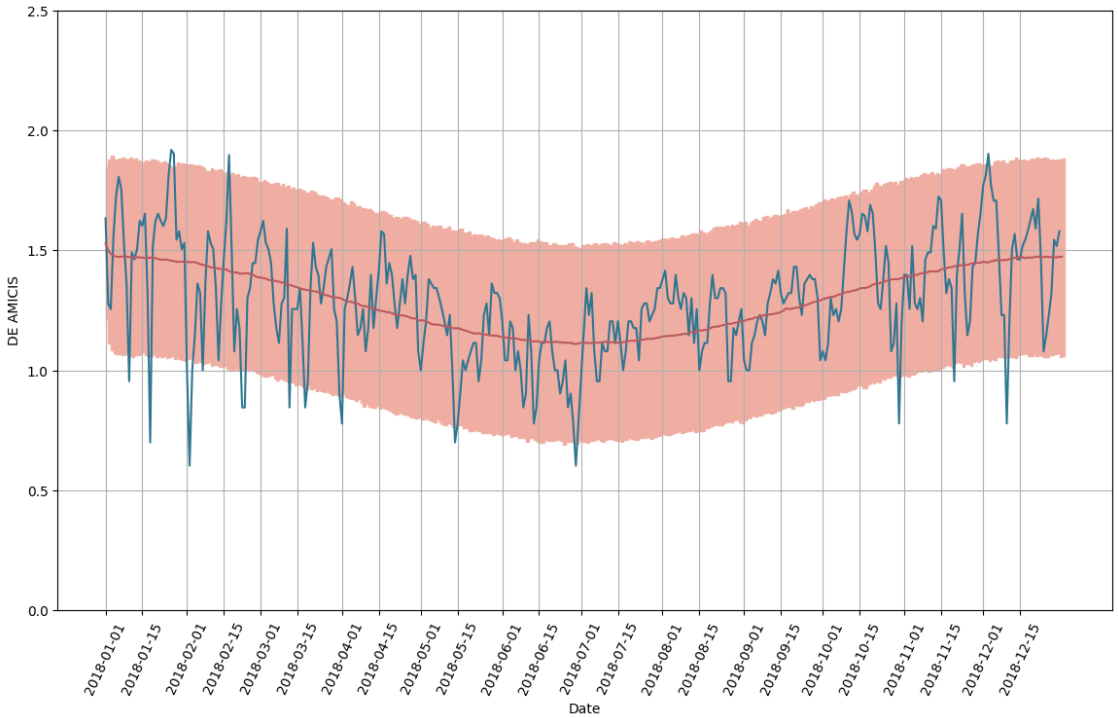
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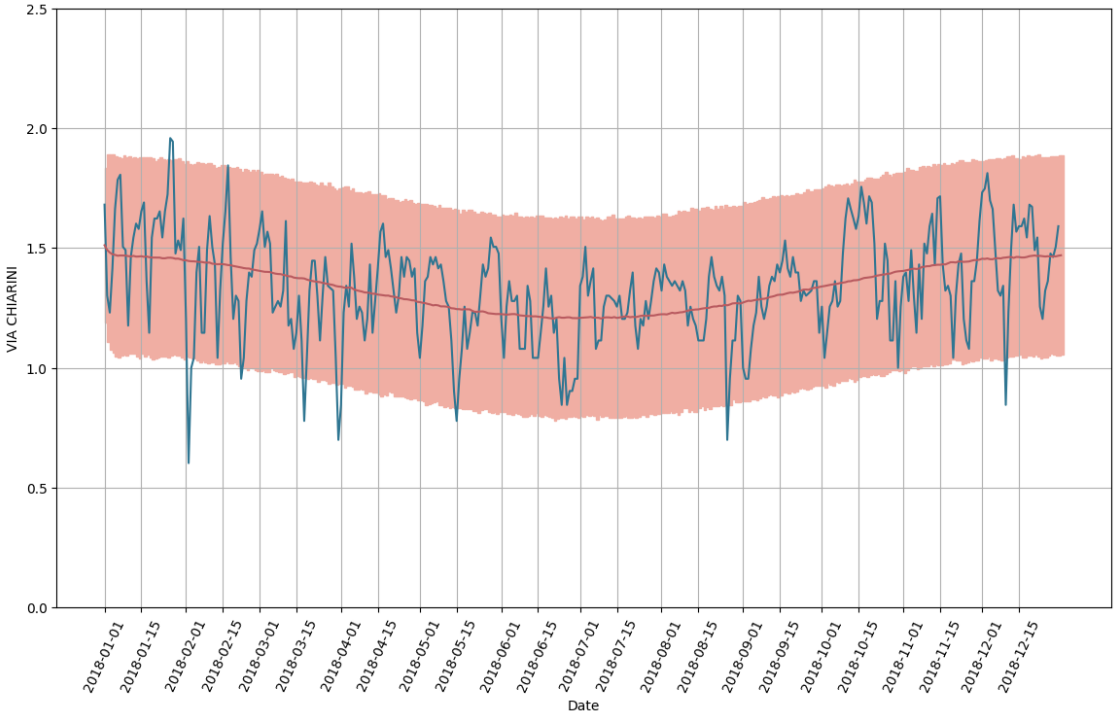
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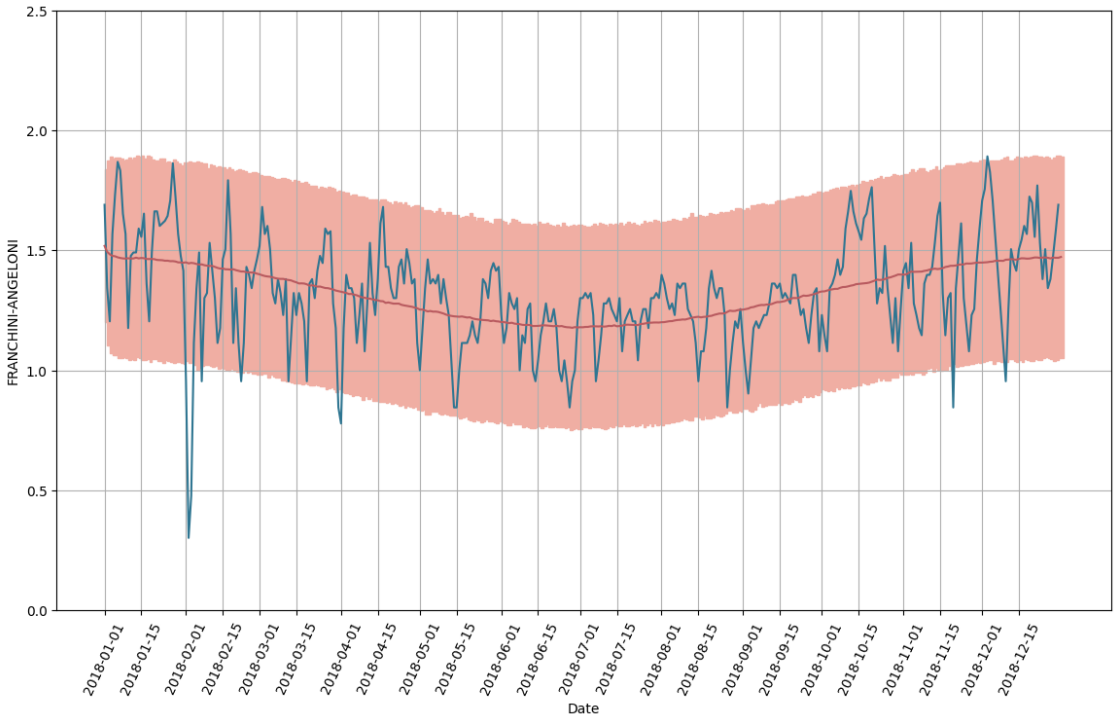
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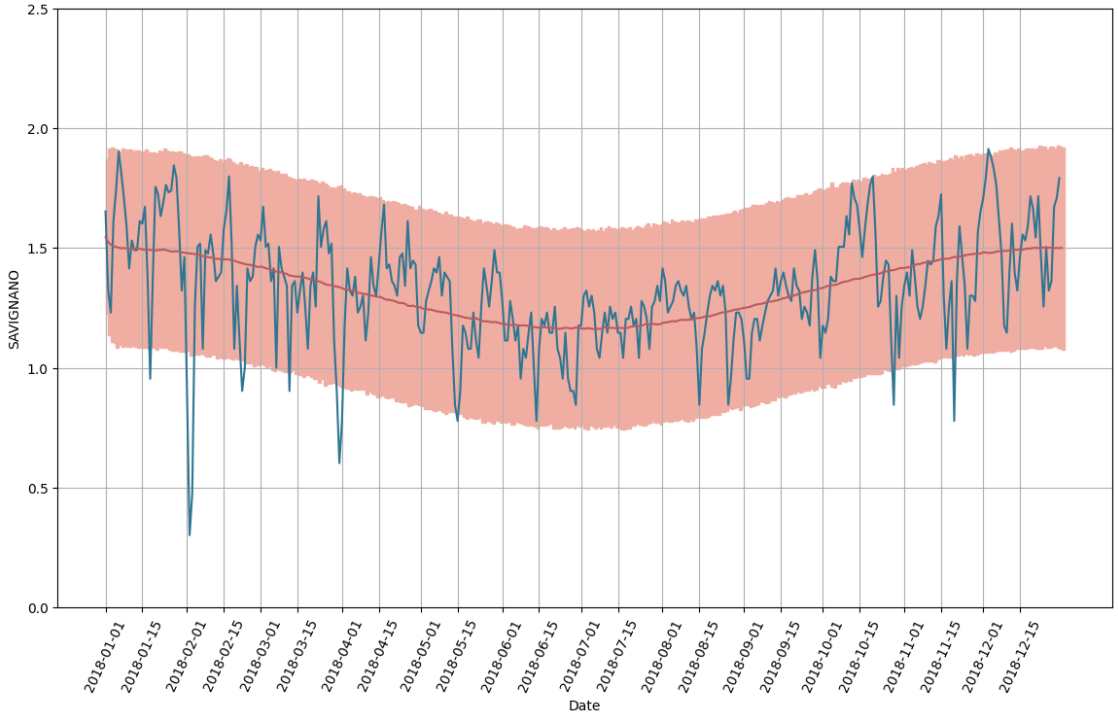
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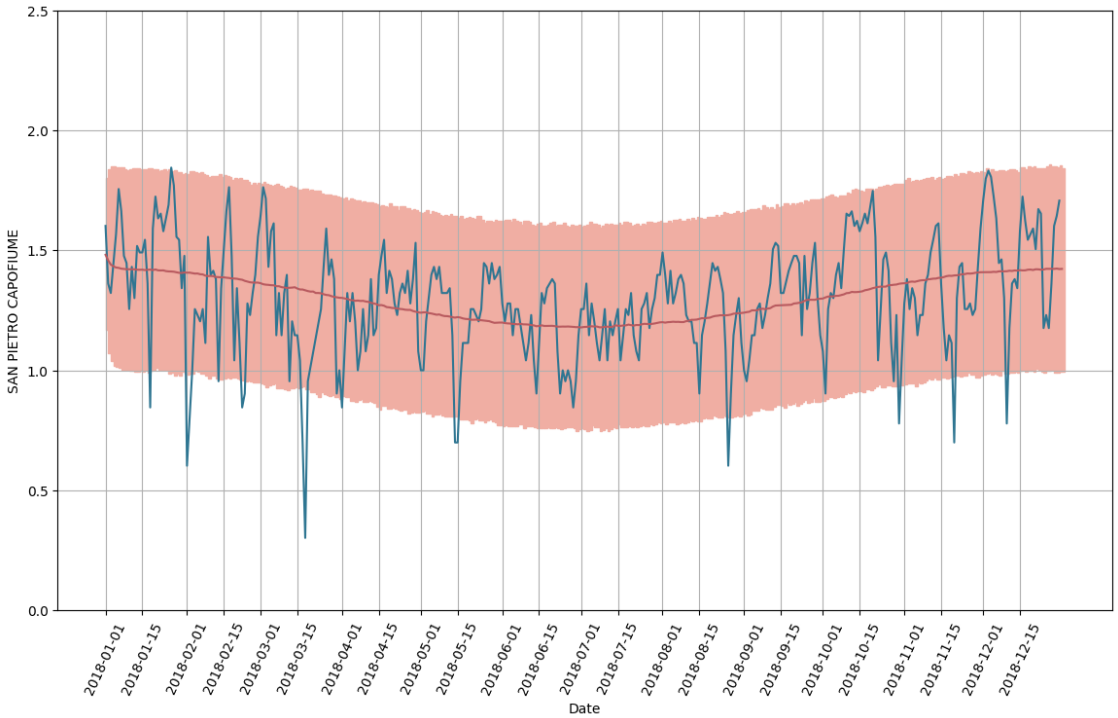
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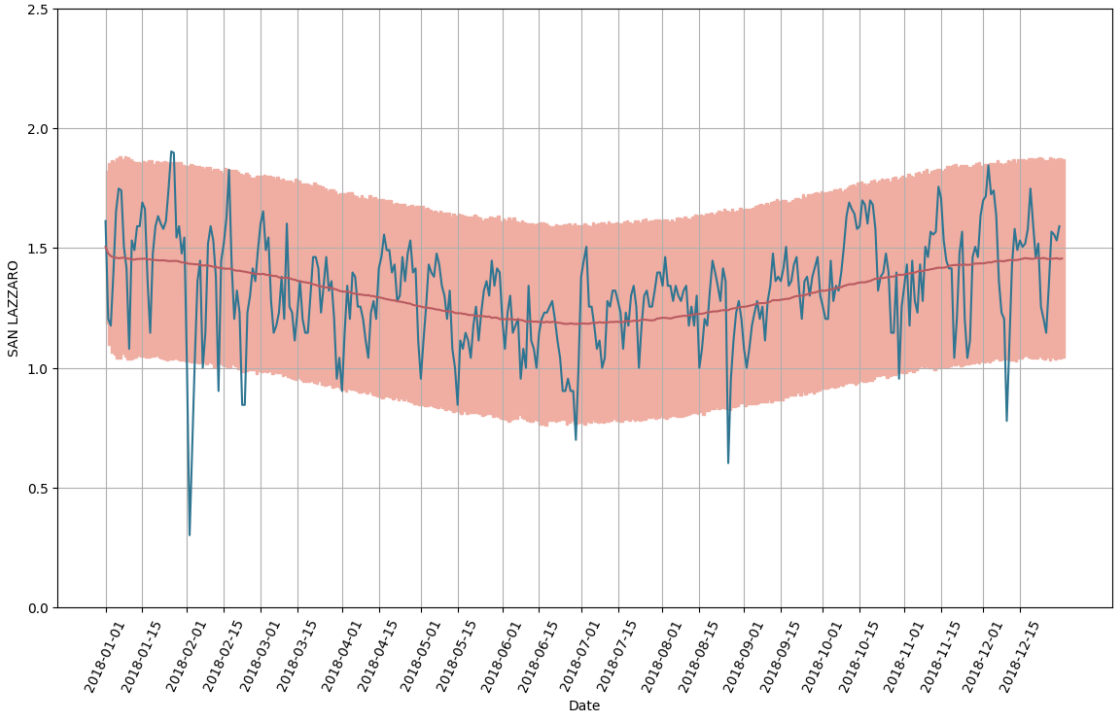
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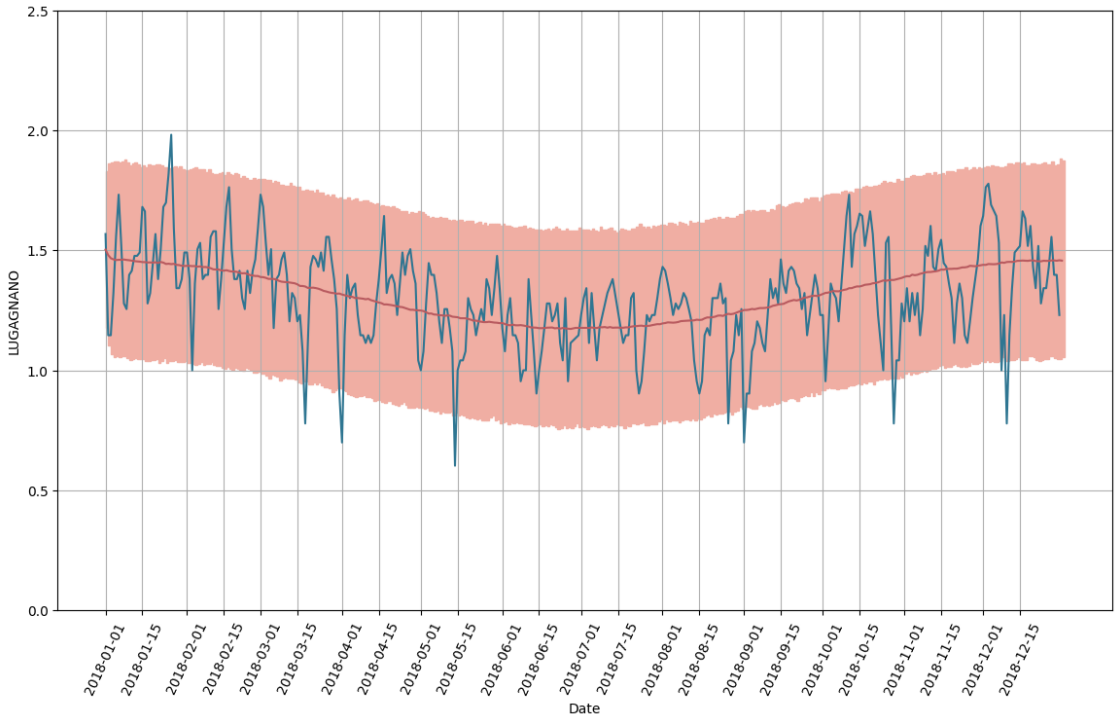
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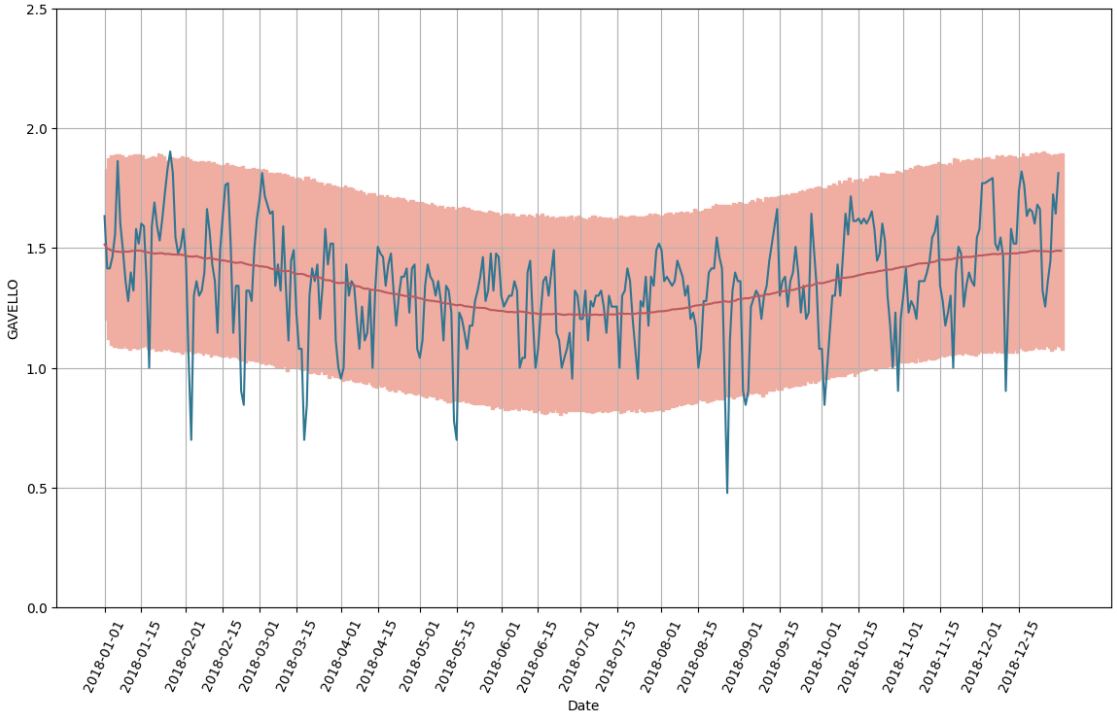
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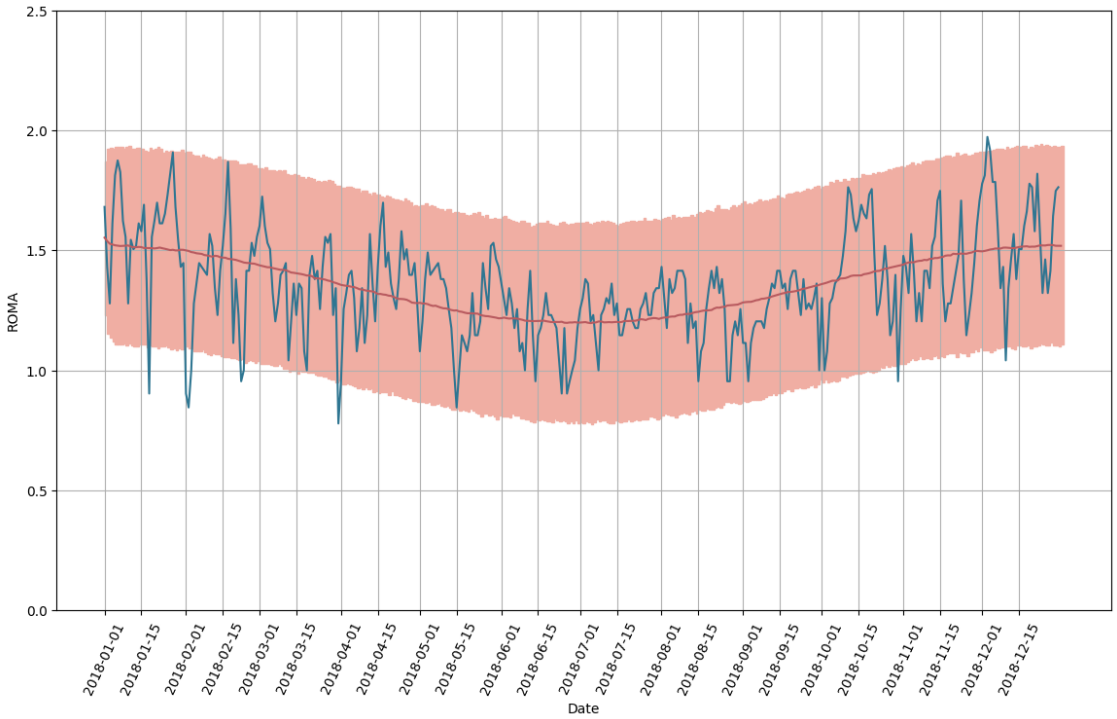
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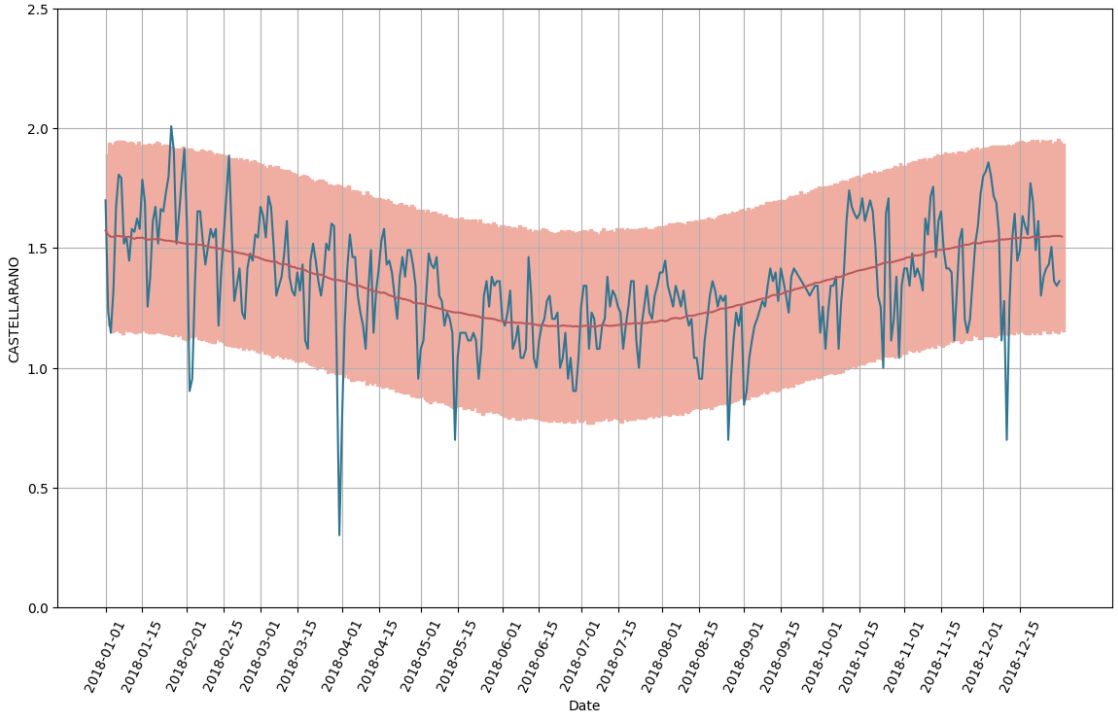
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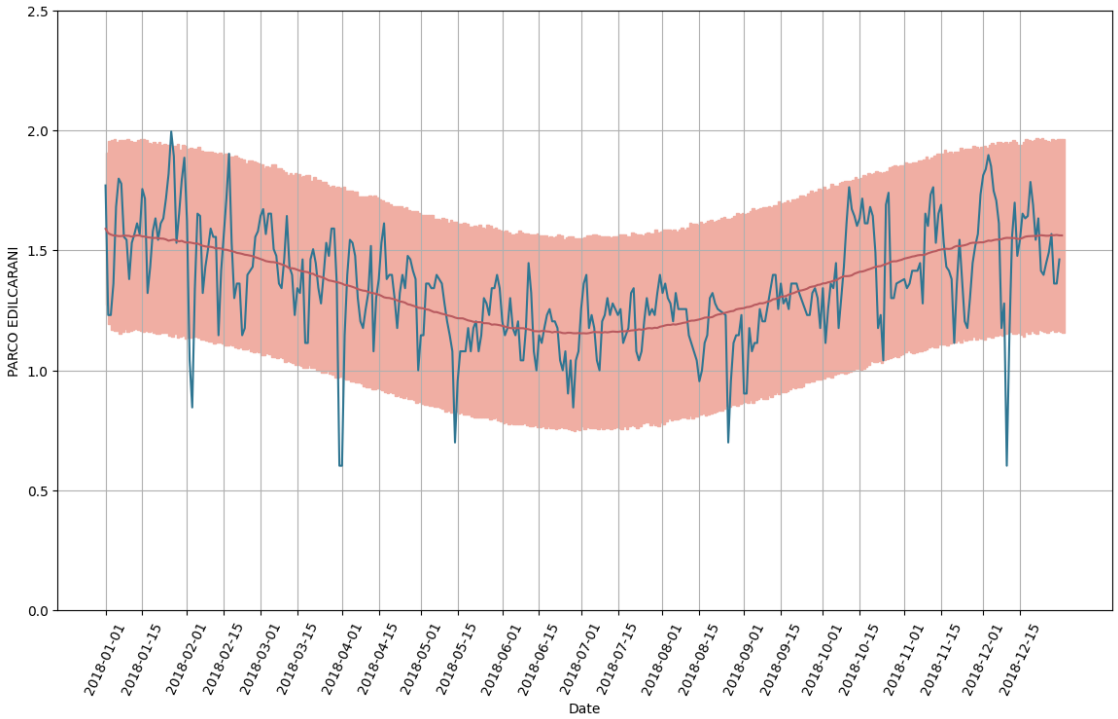
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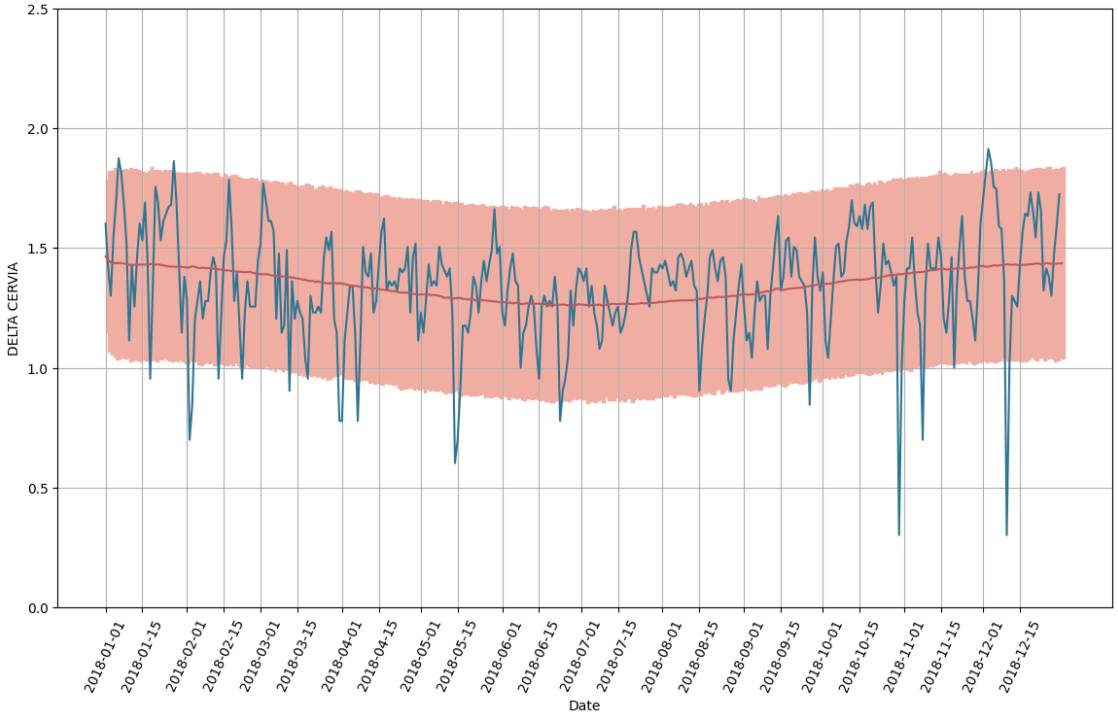
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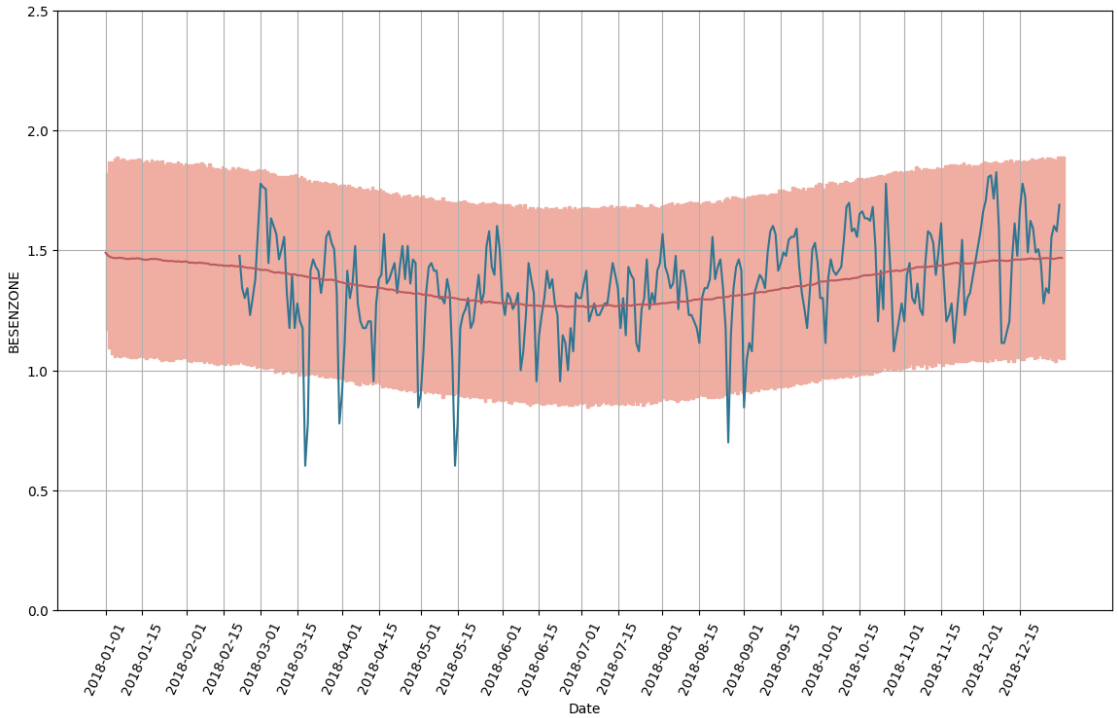
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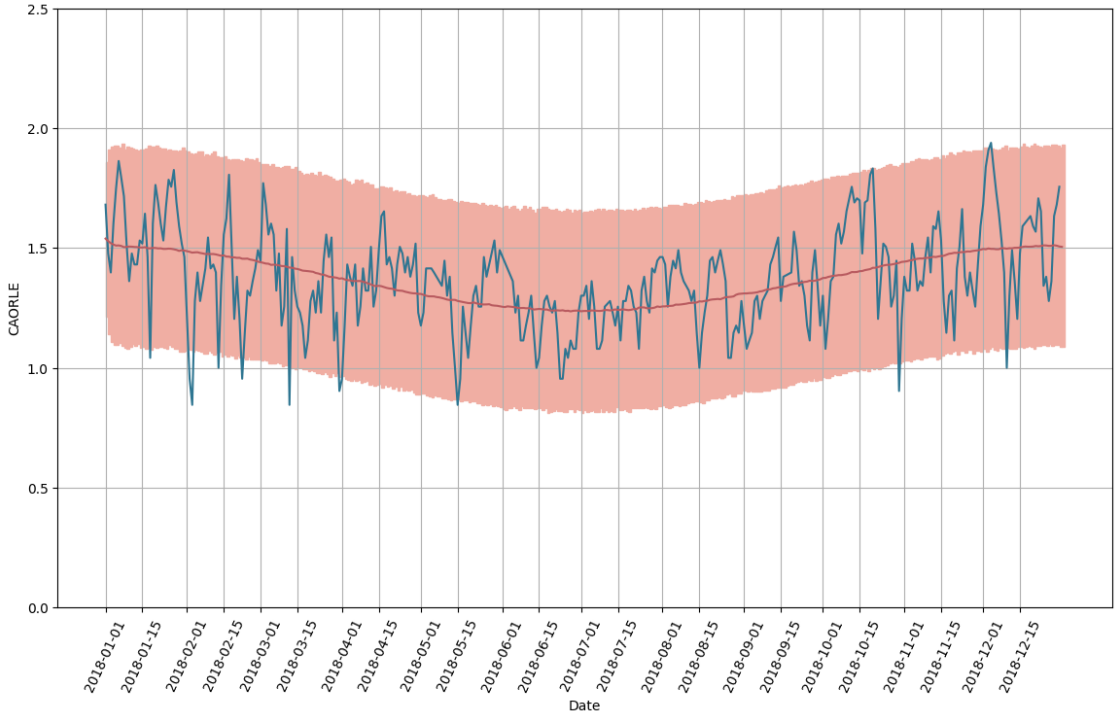
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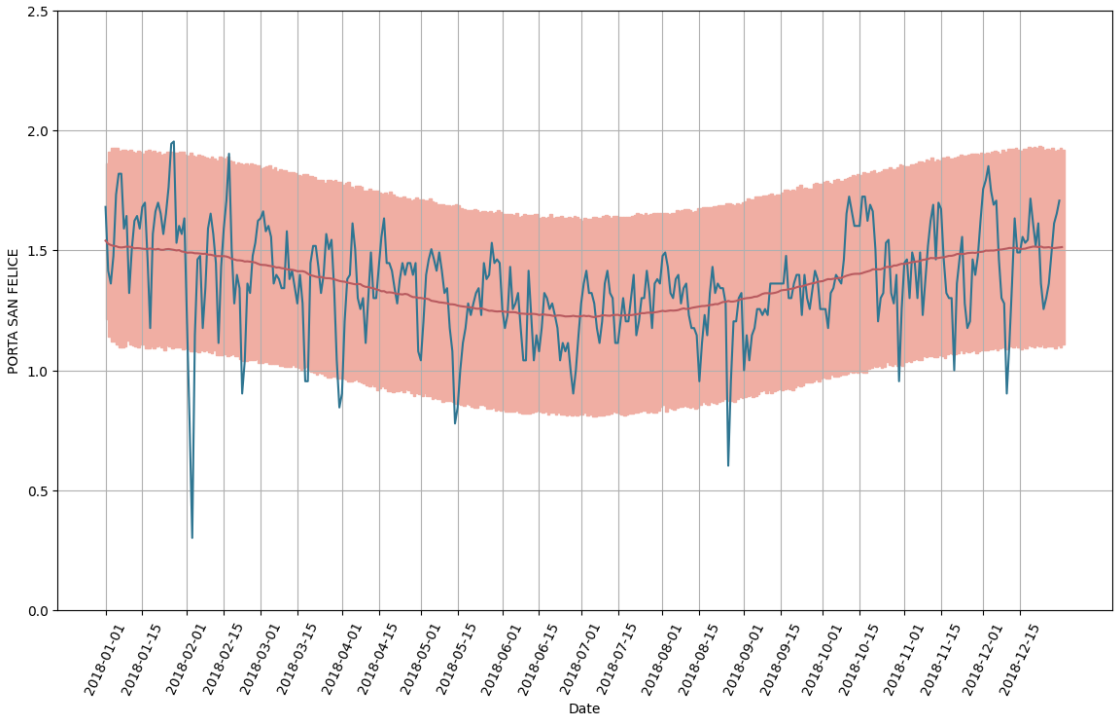
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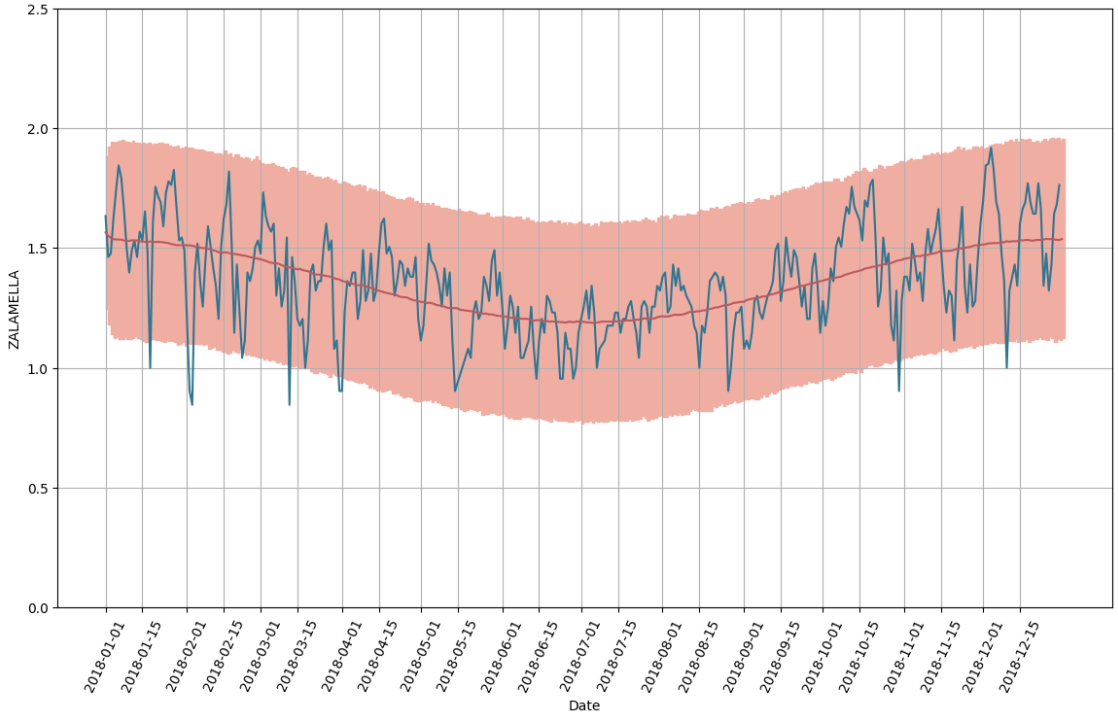
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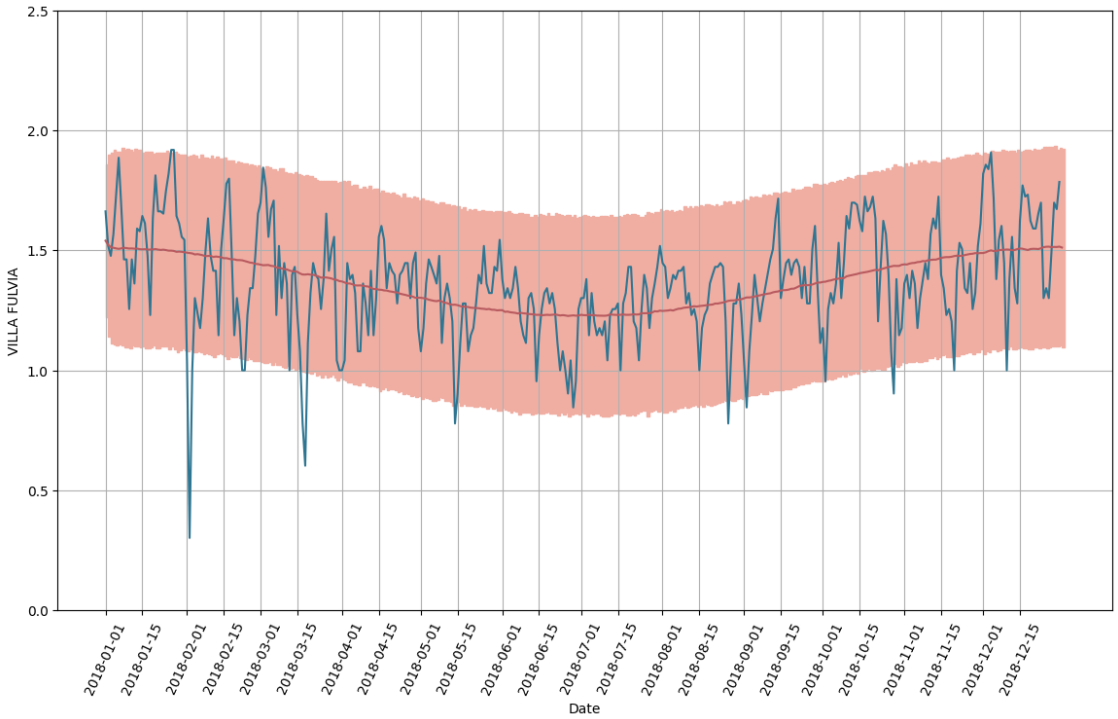
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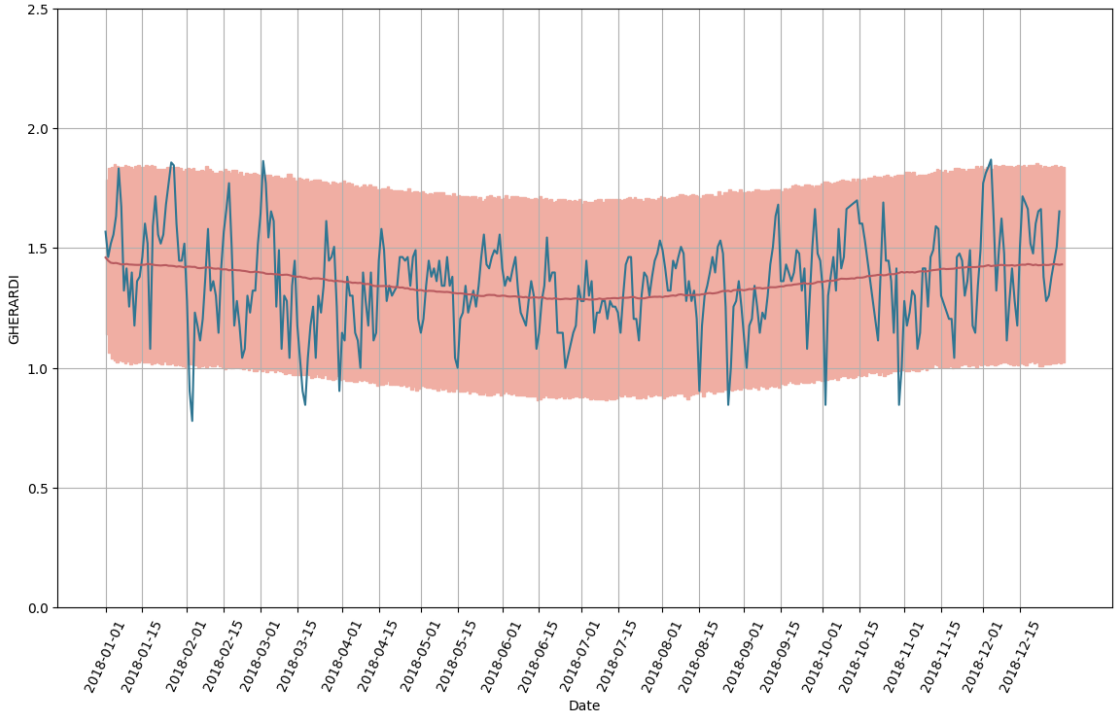
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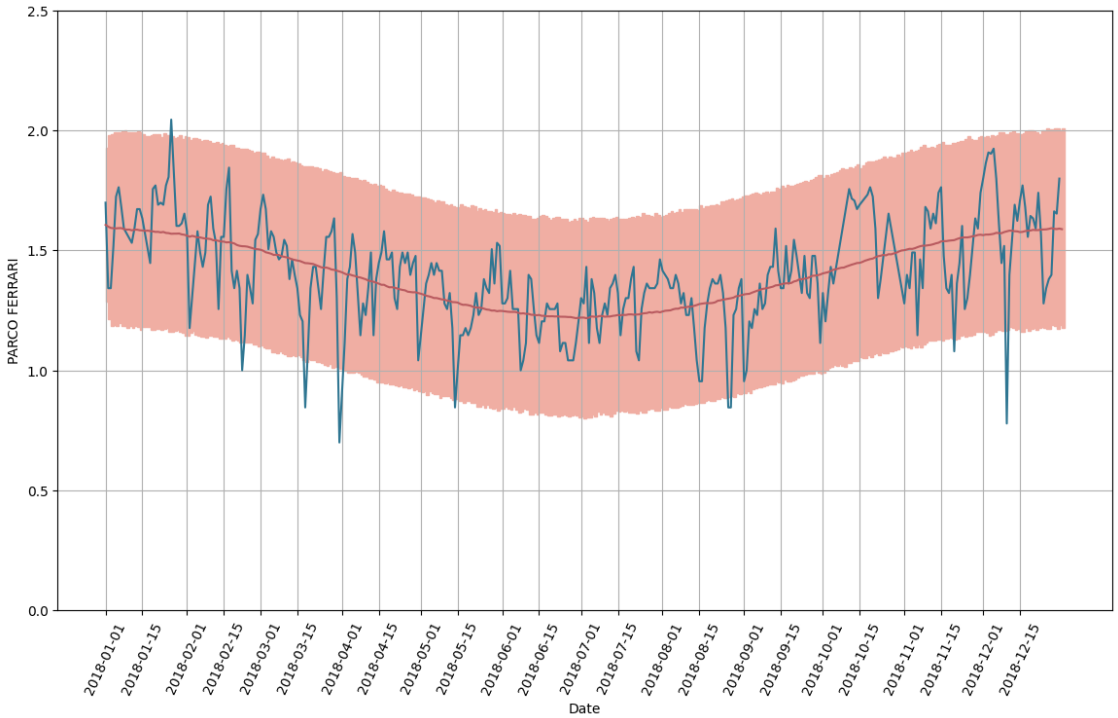
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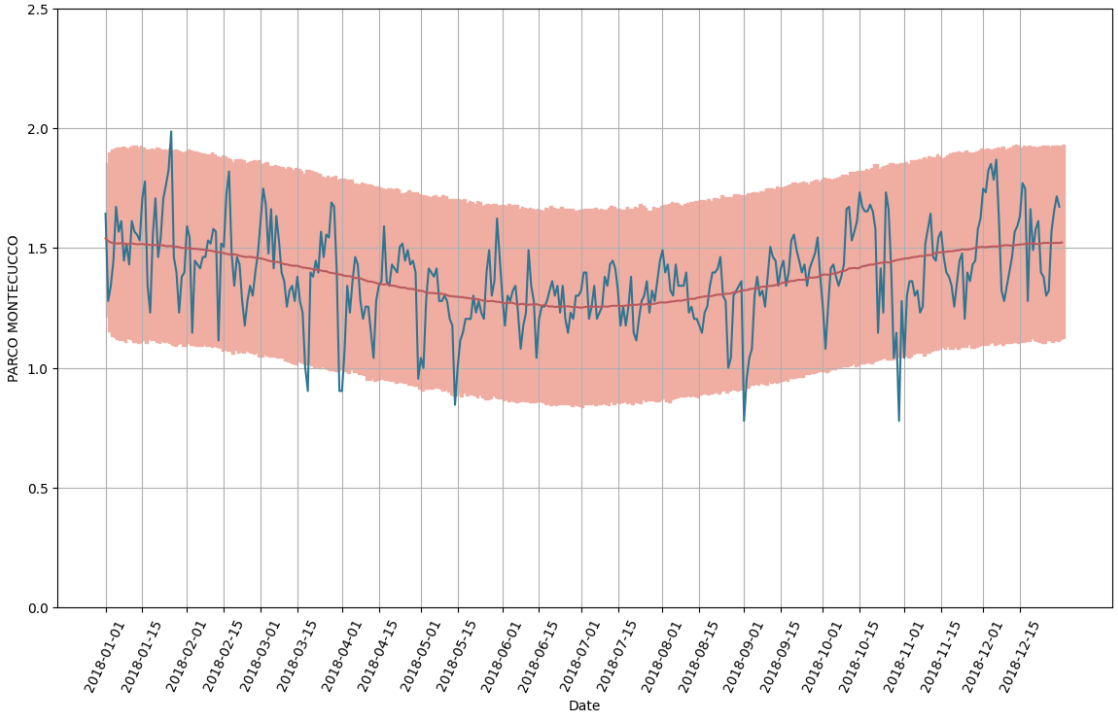
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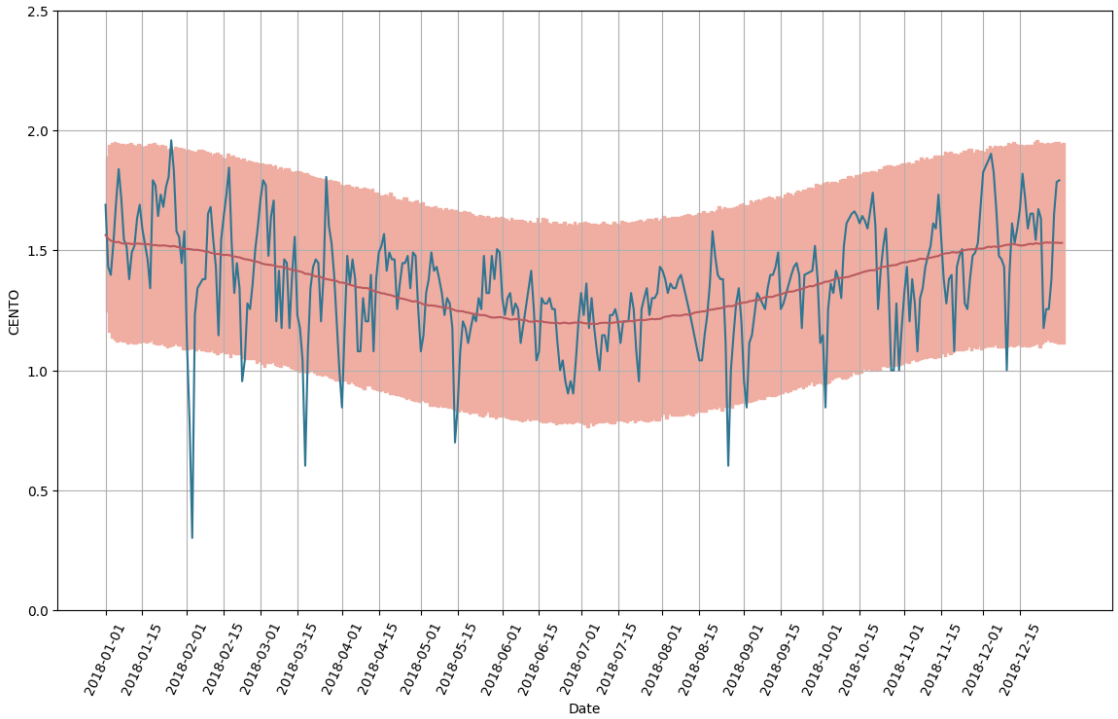
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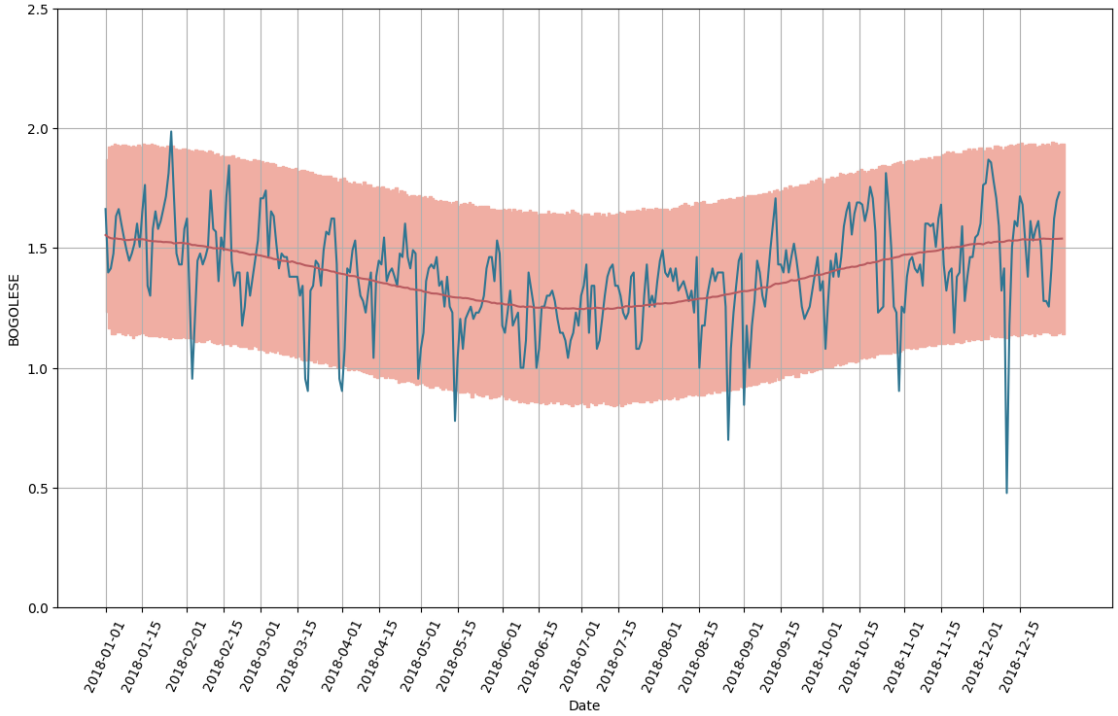
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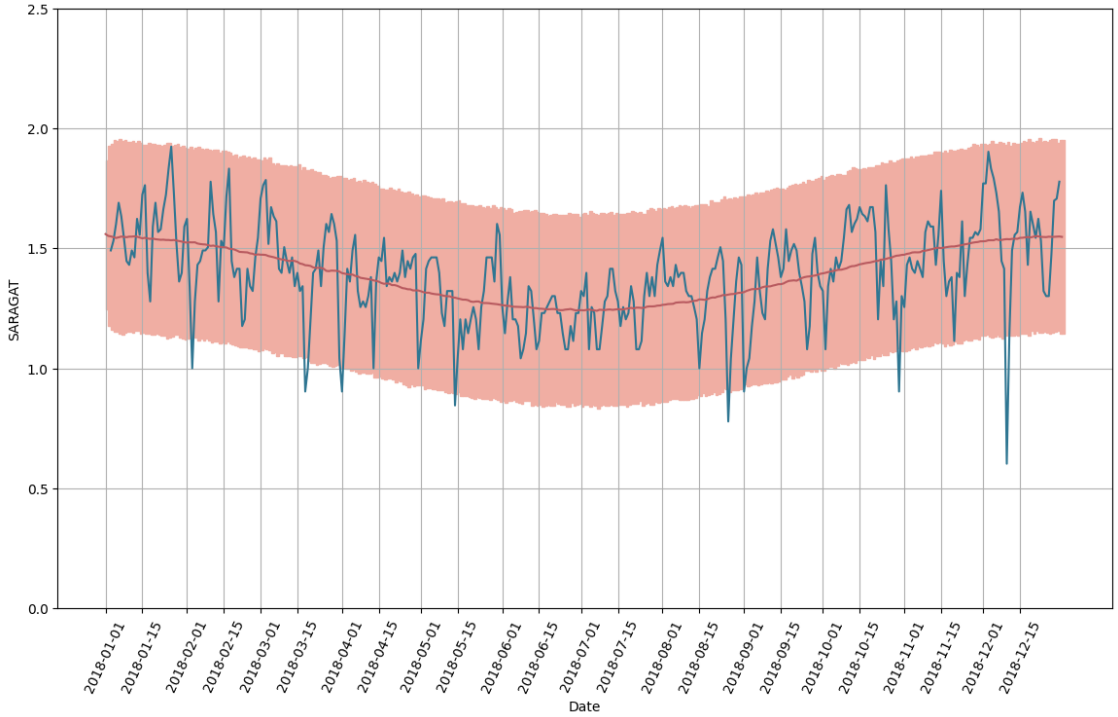
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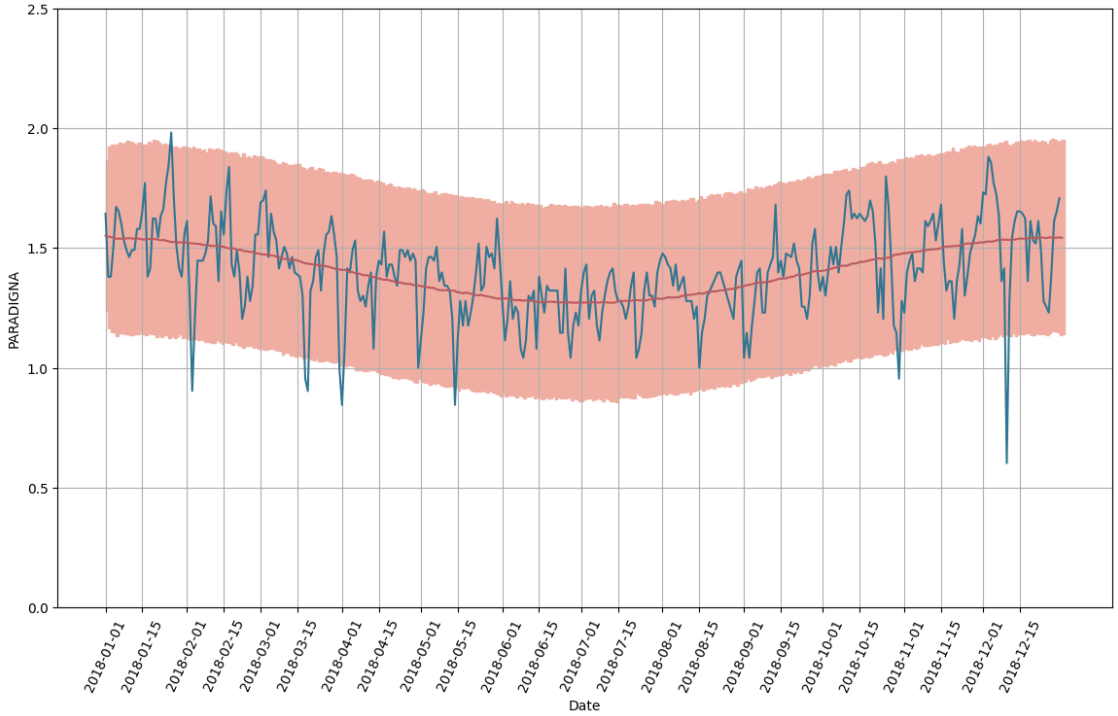
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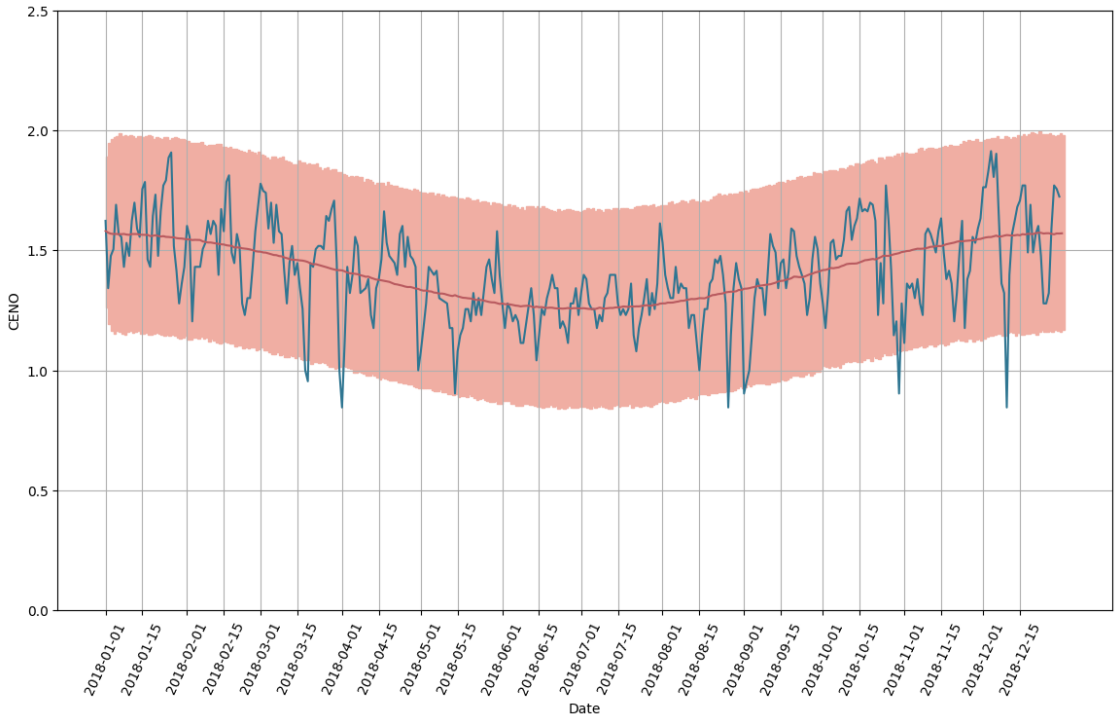
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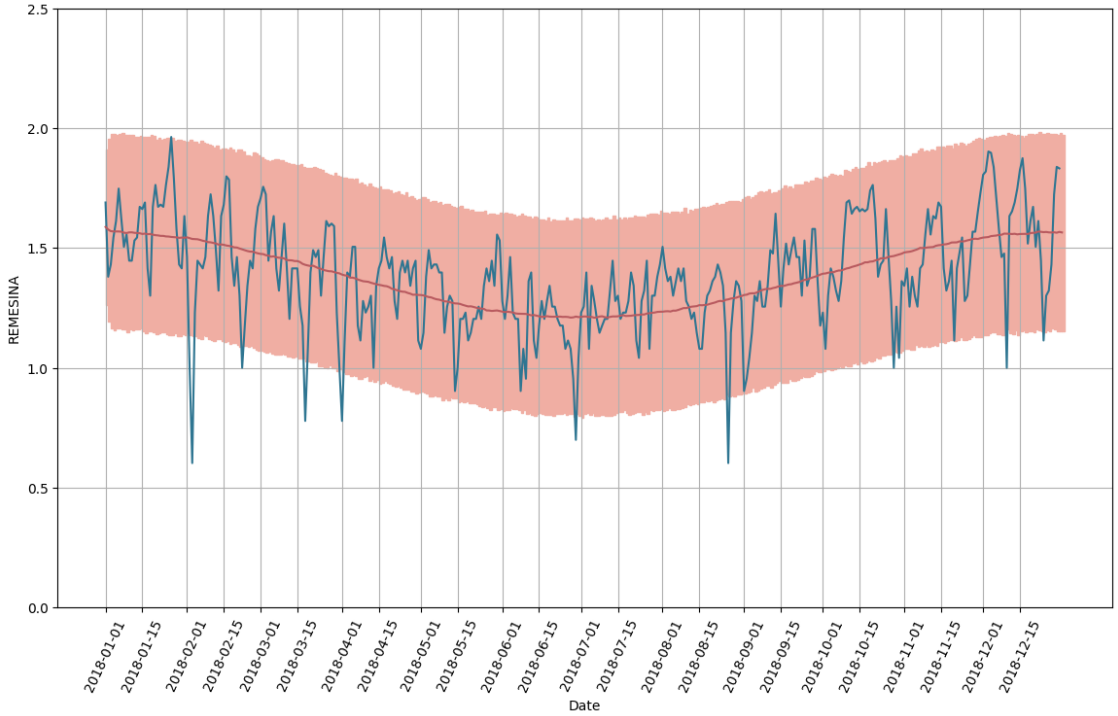
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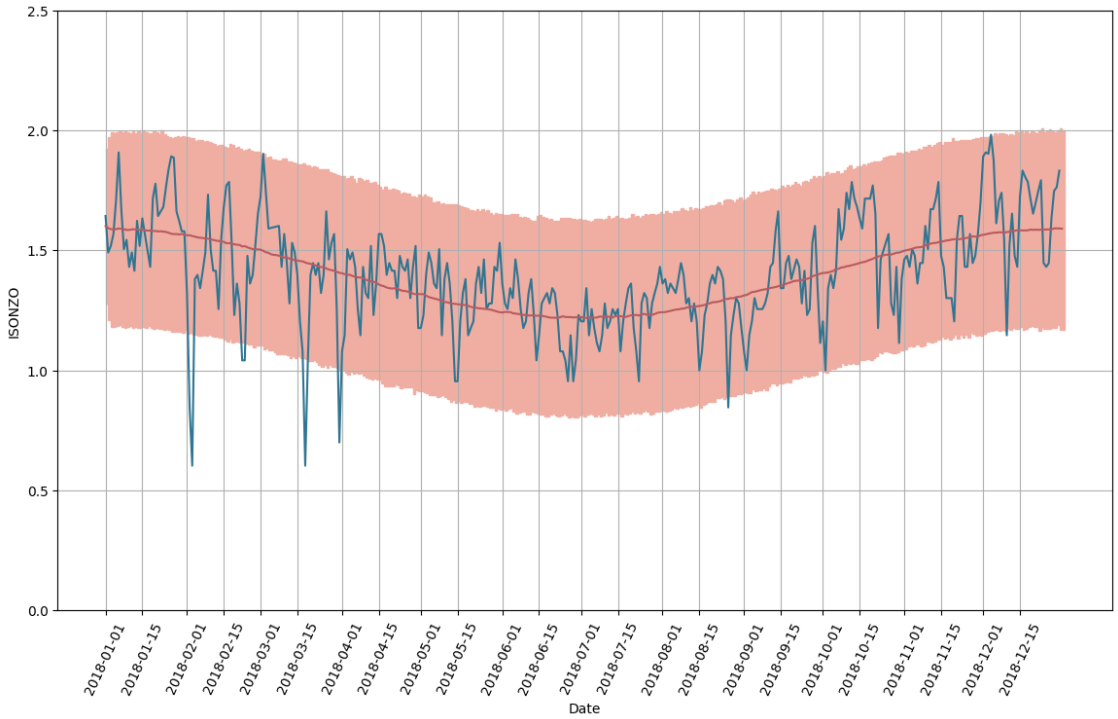
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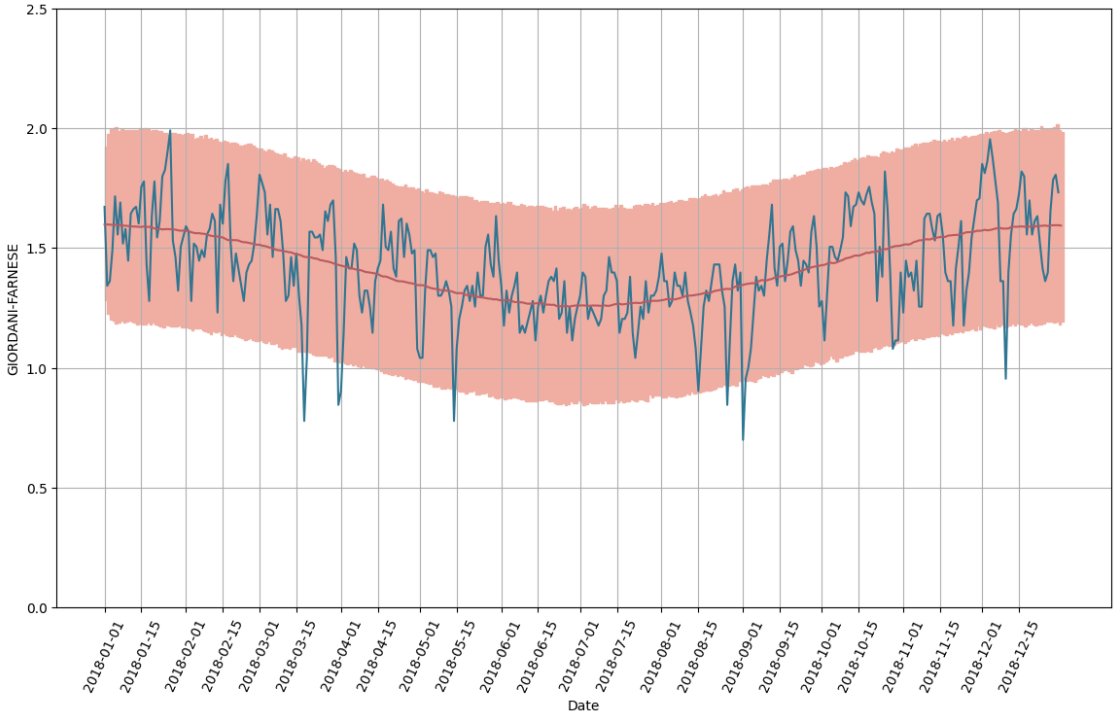
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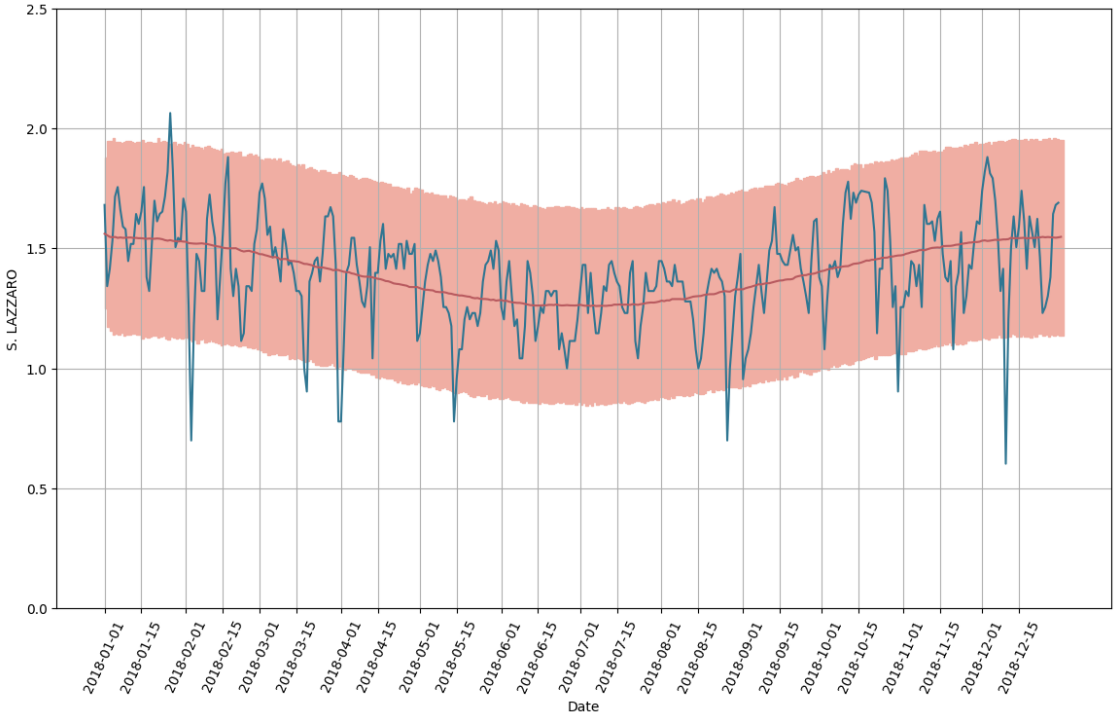
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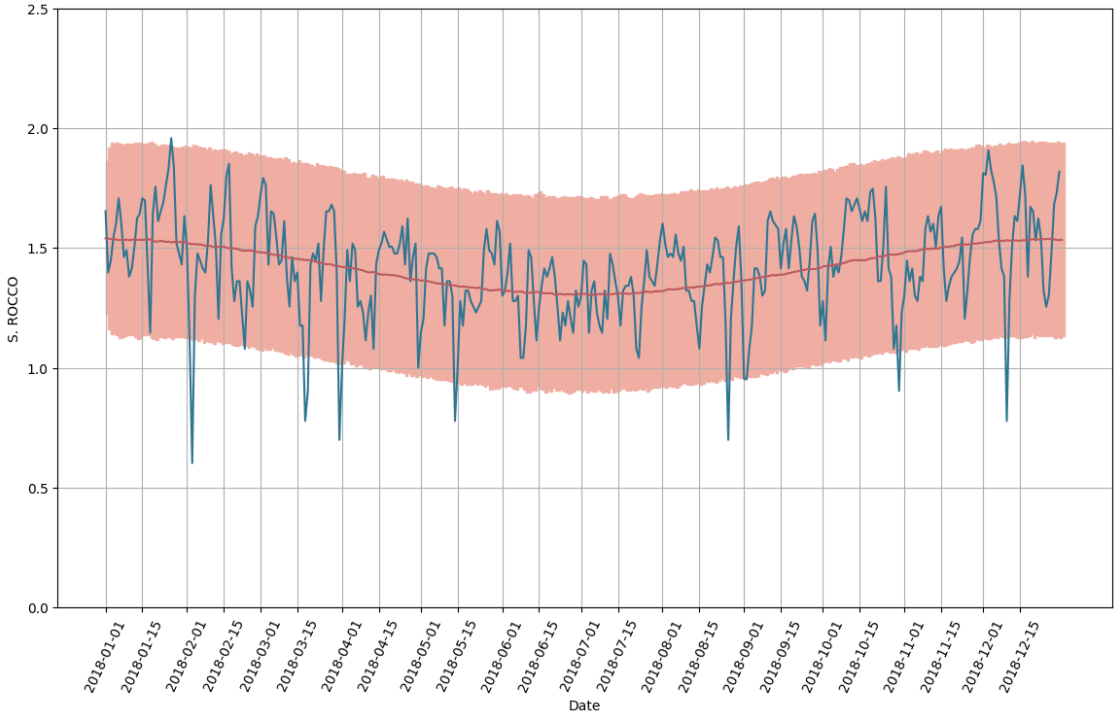
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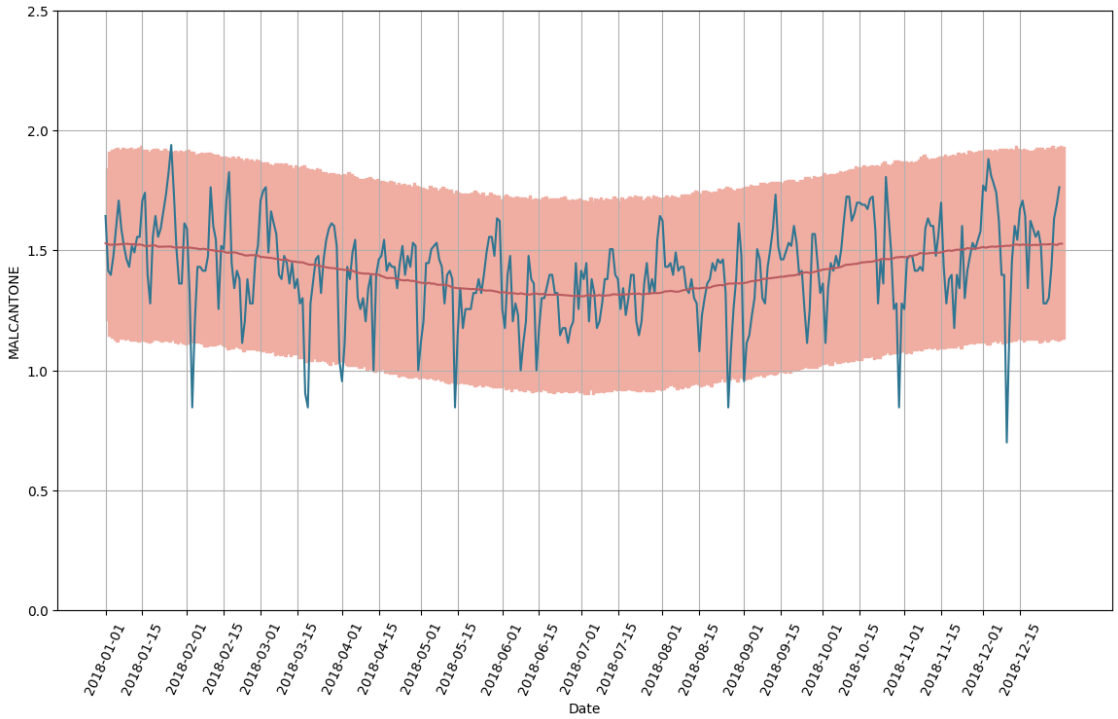
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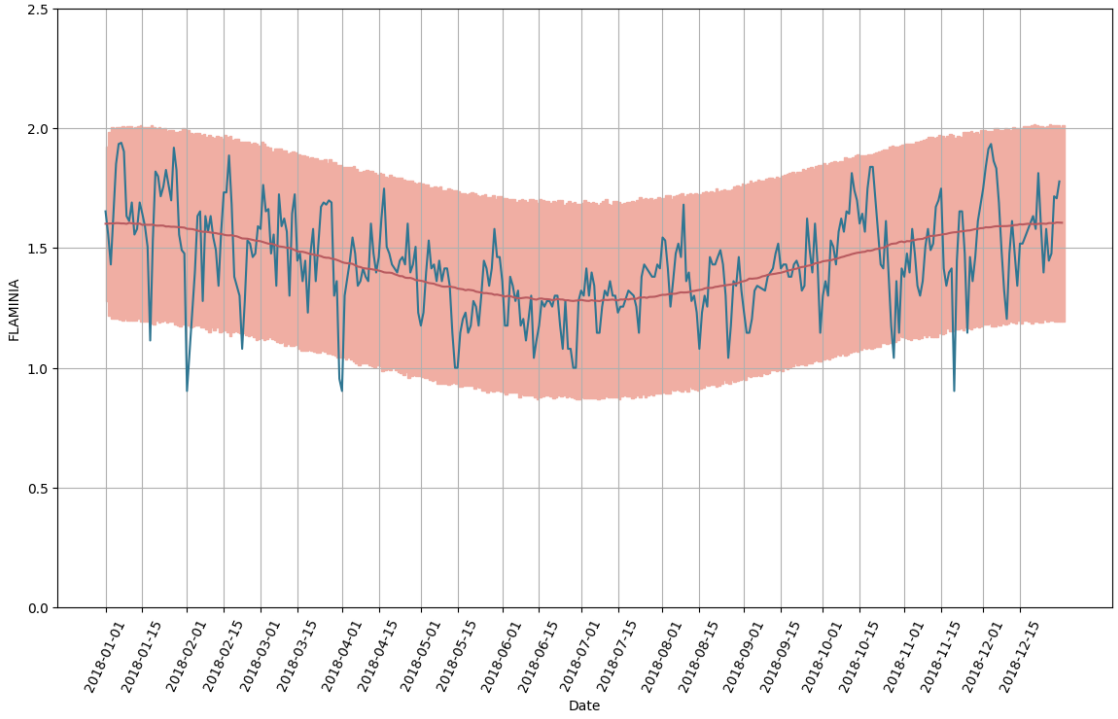
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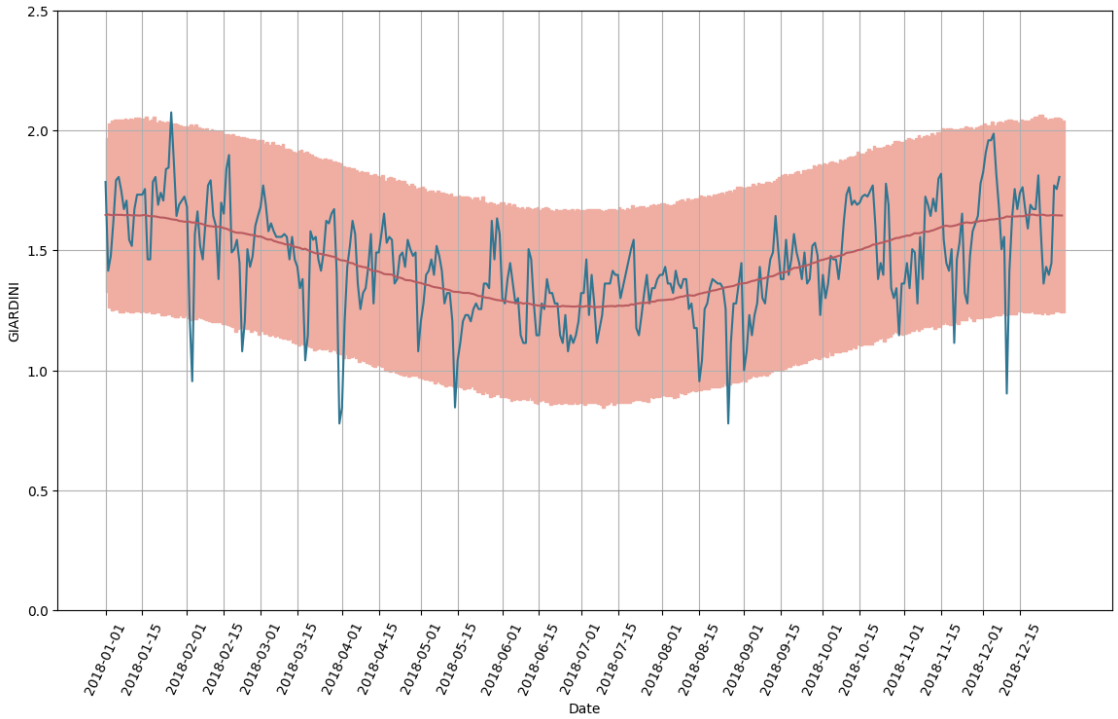
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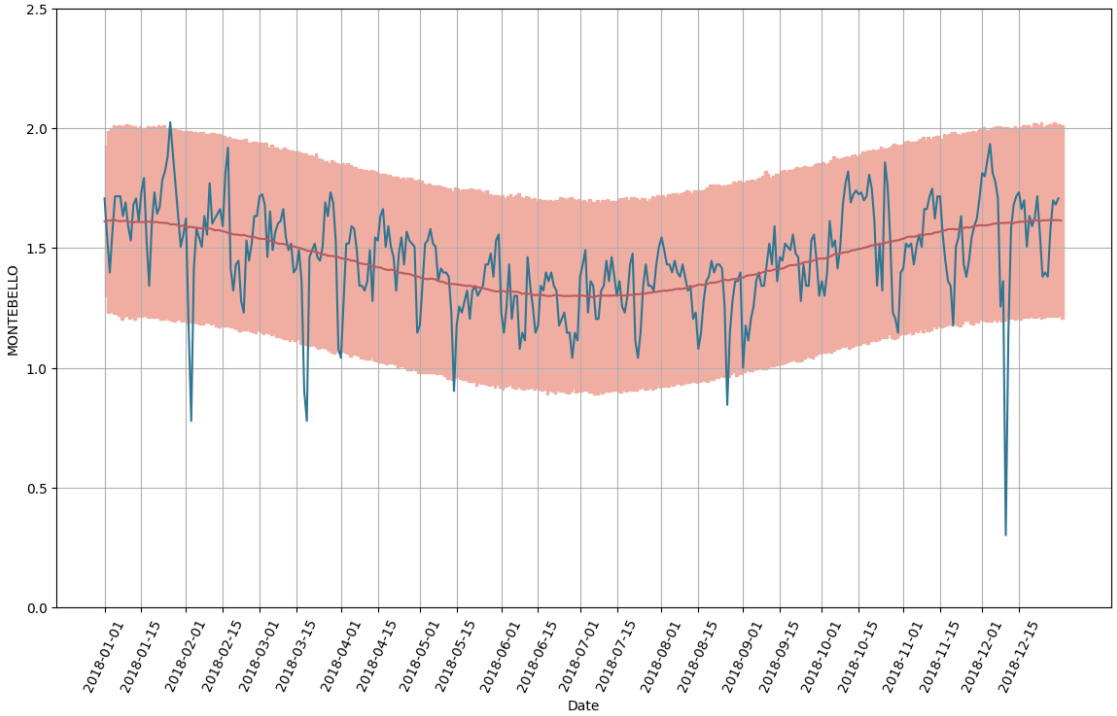
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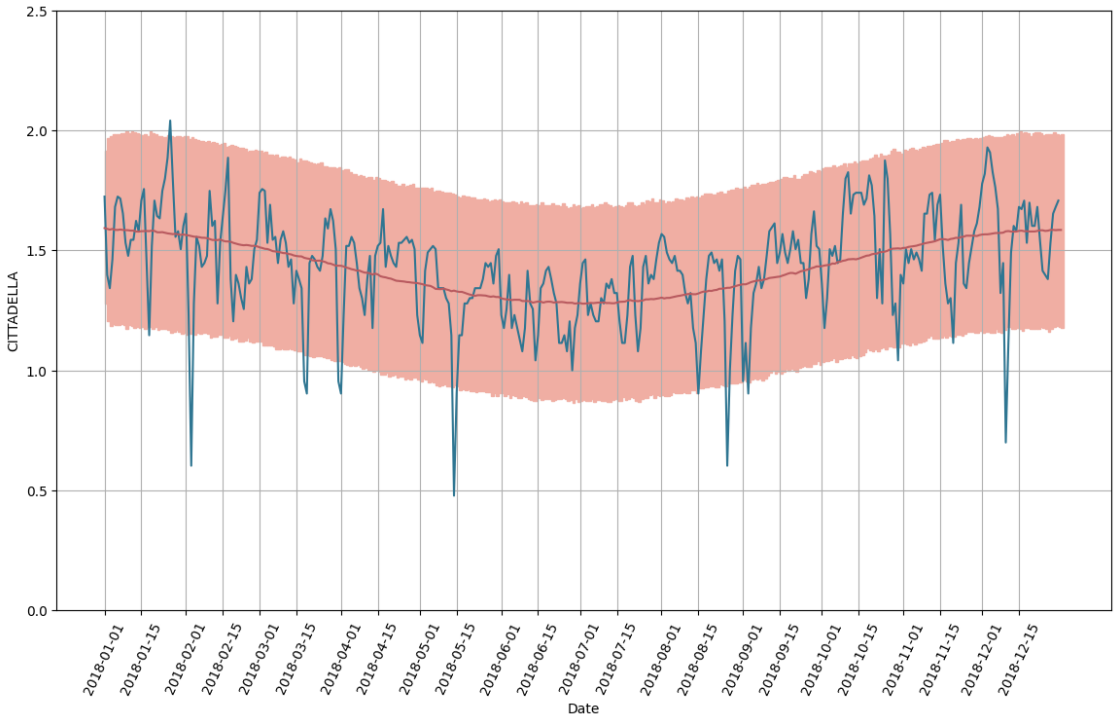
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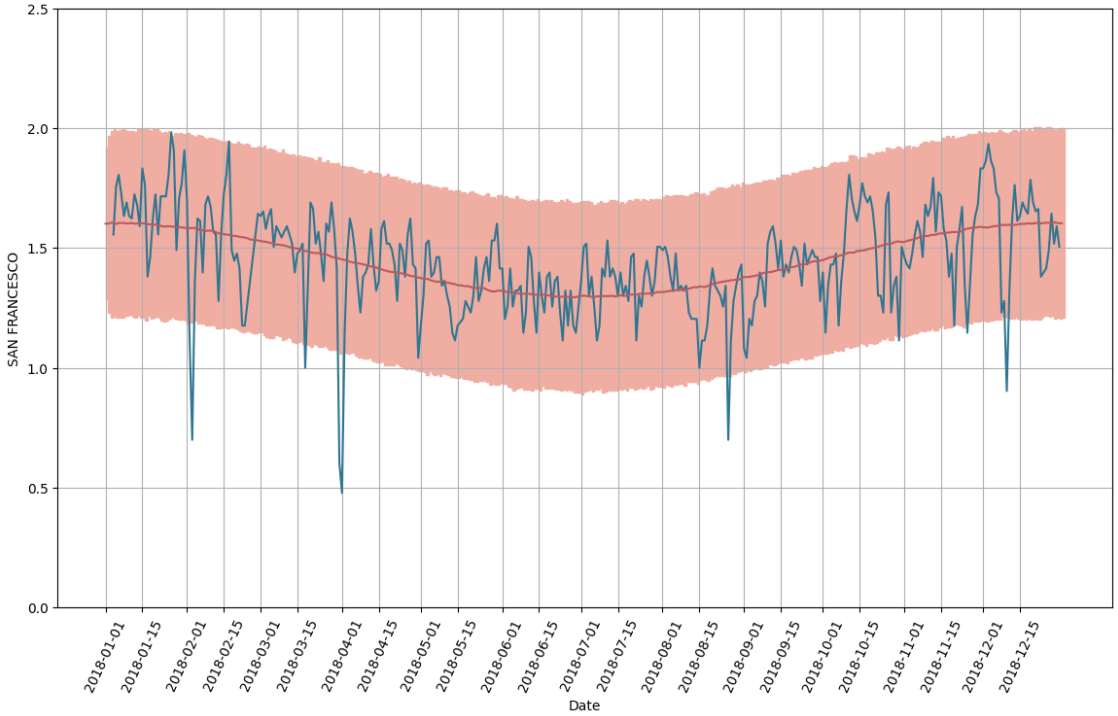
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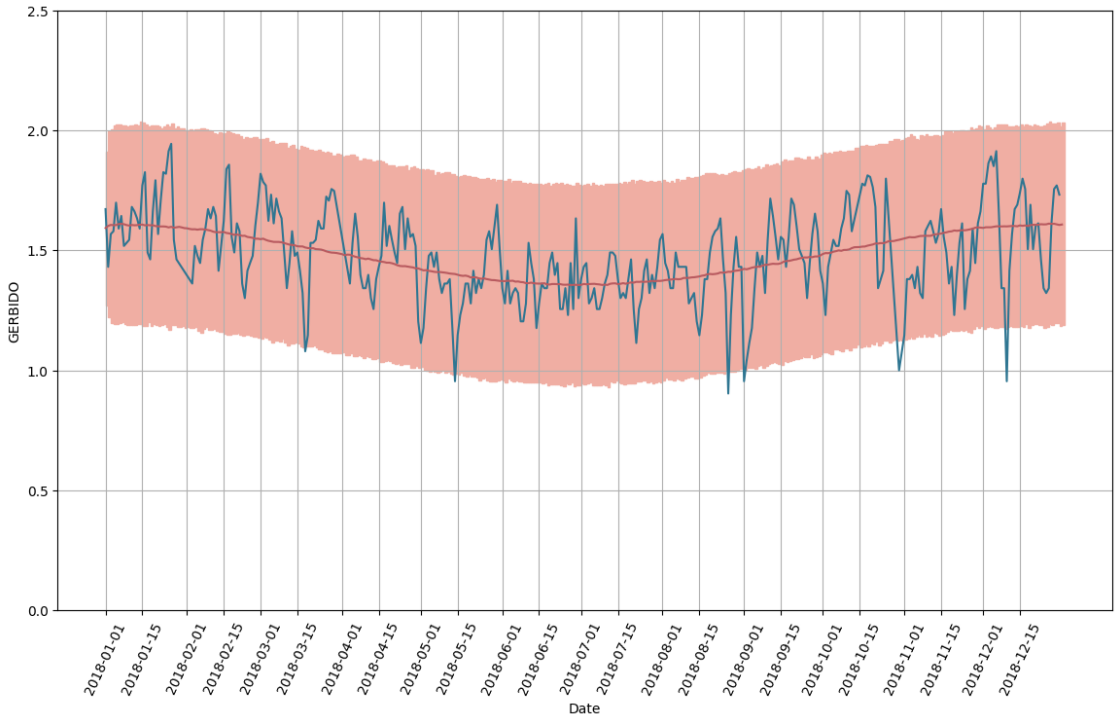
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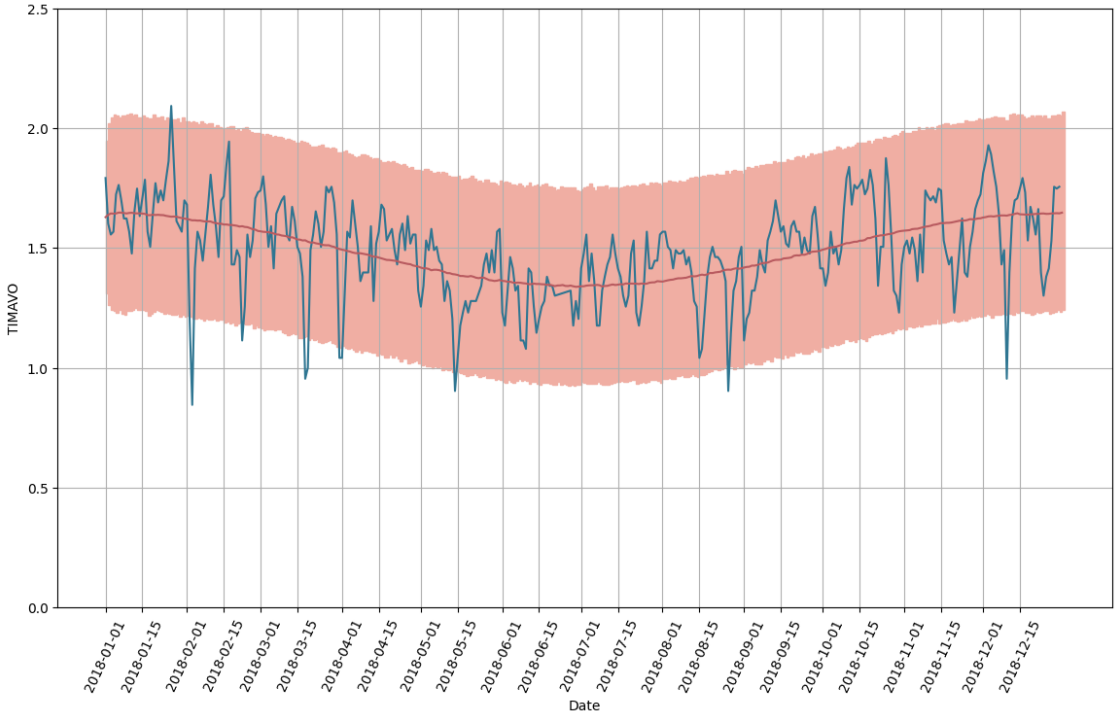
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