prova

February 9, 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=1250, burnin=1000)
```

```
17:17:02 - 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


17:35:25 - cmdstanpy - INFO - CmdStan done processing.
17:35:25 - cmdstanpy - WARNING - Non-fatal error during sampling:
Exception: normal_lpdf: Scale parameter is 0, but must be positive! (in '/home/b
r1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/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/git_bayesian_copie/ARIMA/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/git_bayesian_copie/ARIMA/NoCovariates/code
.stan', line 157, column 4 to column 34)
        Exception: code_model_namespace::log_prob: phi[1][3] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
git_bayesian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column
```

```
47)
Exception: normal_lpdf: Scale parameter is -0.687949, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoCovariates/code
.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -1.7316, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/code.stan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[1][2] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/git_bay
esian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: normal_lpdf: Scale parameter is -24.4747, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -4.71381, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/code.stan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[1][2] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
git_bayesian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column
47)
        Exception: code_model_namespace::log_prob: phi[1][30] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/git_bay
esian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column 47)
Exception: normal_lpdf: Scale parameter is -0.939195, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoCovariates/code
.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -1.2321, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/code.stan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[2][1] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/git_bay
esian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: code_model_namespace::log_prob: phi[1][5] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/git_bay
esian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column 47)
Exception: normal_lpdf: Scale parameter is -0.780896, but must be positive! (in
'/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoCovariates/code
.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.675852, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/code.stan', line 143, column 4 to column 61)
        Exception: code_model_namespace::log_prob: phi[2][1] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
git_bayesian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column
47)
        Exception: code_model_namespace::log_prob: phi[2][1] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
git_bayesian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column
```

```
47)
        Exception: code_model_namespace::log_prob: phi[2][1] is 1, but must be
less than or equal to 1.000000 (in '/home/br1/PythonProjects/PythonStats/git_bay
esian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column 47)
        Exception: code_model_namespace::log_prob: phi[1][9] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
git_bayesian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column
47)
        Exception: code_model_namespace::log_prob: phi[2][1] is -nan, but must
be greater than or equal to -1.000000 (in '/home/br1/PythonProjects/PythonStats/
git_bayesian_copie/ARIMA/NoCovariates/code.stan', line 83, column 2 to column
47)
        Exception: normal_lpdf: Scale parameter is -0.00272799, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/code.stan', line 143, column 4 to column 61)
        Exception: normal_lpdf: Scale parameter is -0.00711351, but must be
positive! (in '/home/br1/PythonProjects/PythonStats/git_bayesian_copie/ARIMA/NoC
ovariates/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/git_bayesian_copie/ARIMA/NoCovariates/fit_a
rima.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: 18:23

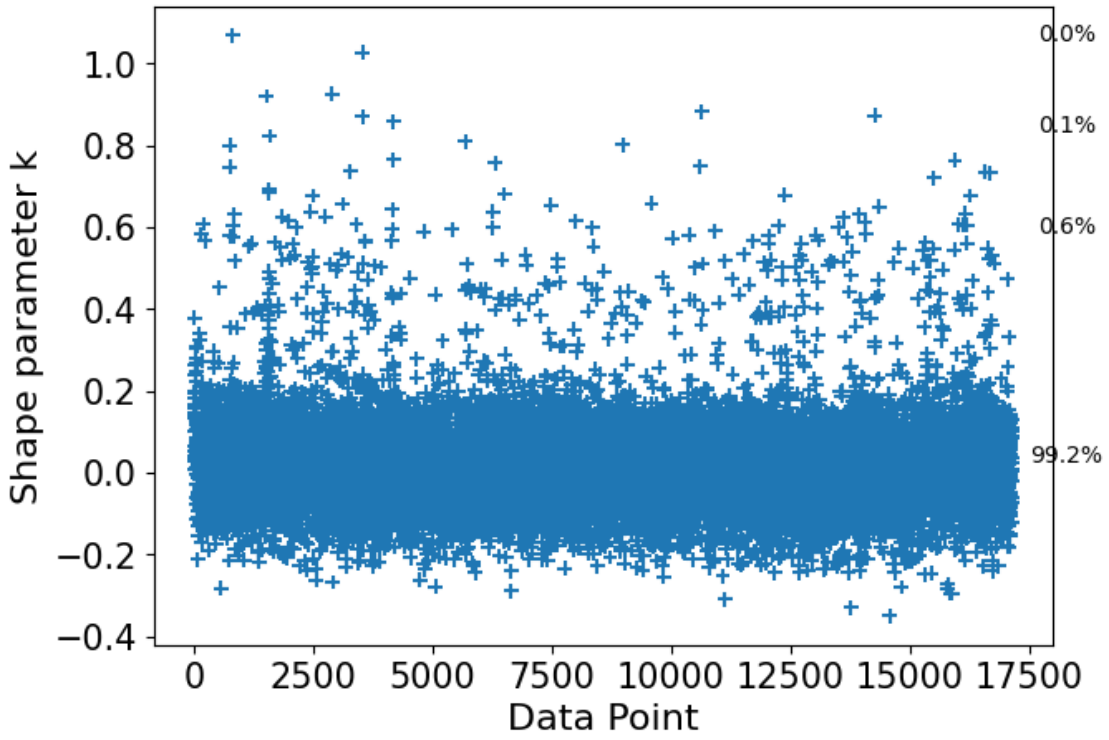
[5]:
```
res = az.loo(ritorno['inference_data'], var_name="log_lik", pointwise=True)
res
```

```
/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 5000 posterior samples and 17148 observations log-likelihood
matrix.

         Estimate       SE
elpd_loo  7287.64   154.66
p_loo      313.24        -
```

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

Pareto k diagnostic values:
                         Count   Pct.
(-Inf, 0.5]   (good)     17017   99.2%
 (0.5, 0.7]   (ok)         110    0.6%
   (0.7, 1]   (bad)         19    0.1%
   (1, Inf)   (very bad)     2    0.0%
```

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

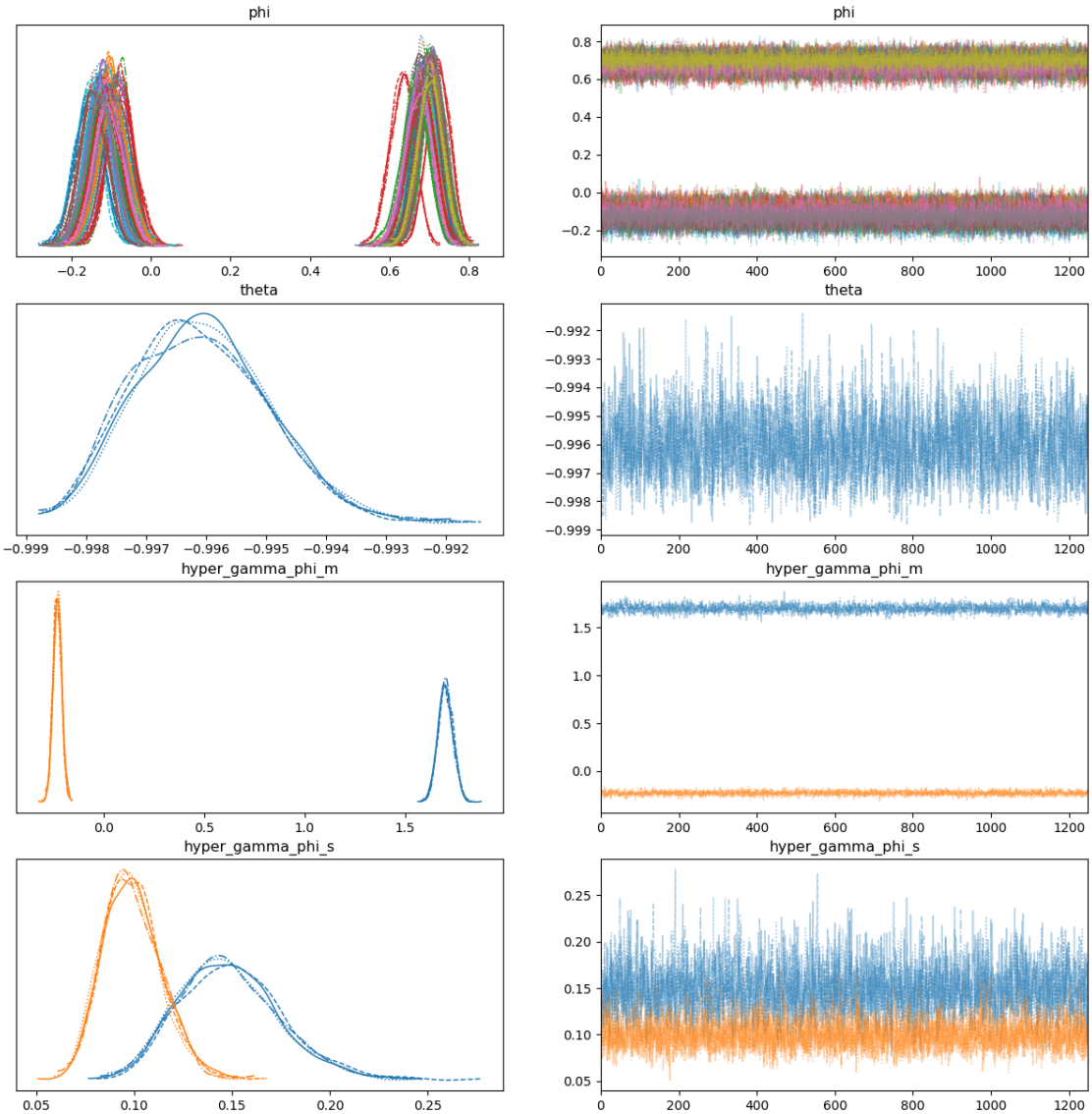


[7]:
```
res = az.waic(ritorno['inference_data'], var_name="log_lik")
res
```

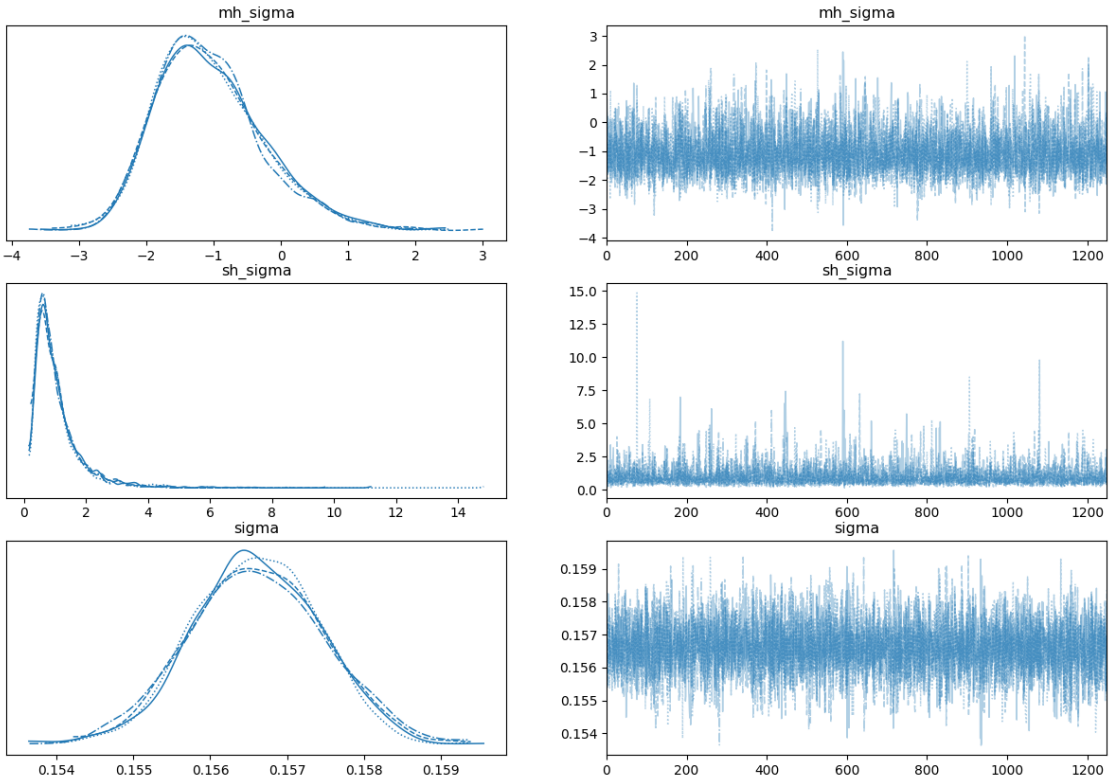
```
/home/br1/PythonProjects/PythonStats/.venv/lib/python3.10/site-
packages/arviz/stats/stats.py:1645: UserWarning: For one or more samples the
posterior variance of the log predictive densities exceeds 0.4. This could be
indication of WAIC starting to fail.
See http://arxiv.org/abs/1507.04544 for details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

[7]:
```
Computed from 5000 posterior samples and 17148 observations log-likelihood
matrix.

          Estimate       SE
elpd_waic  7301.79   154.50
p_waic      299.09        -

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

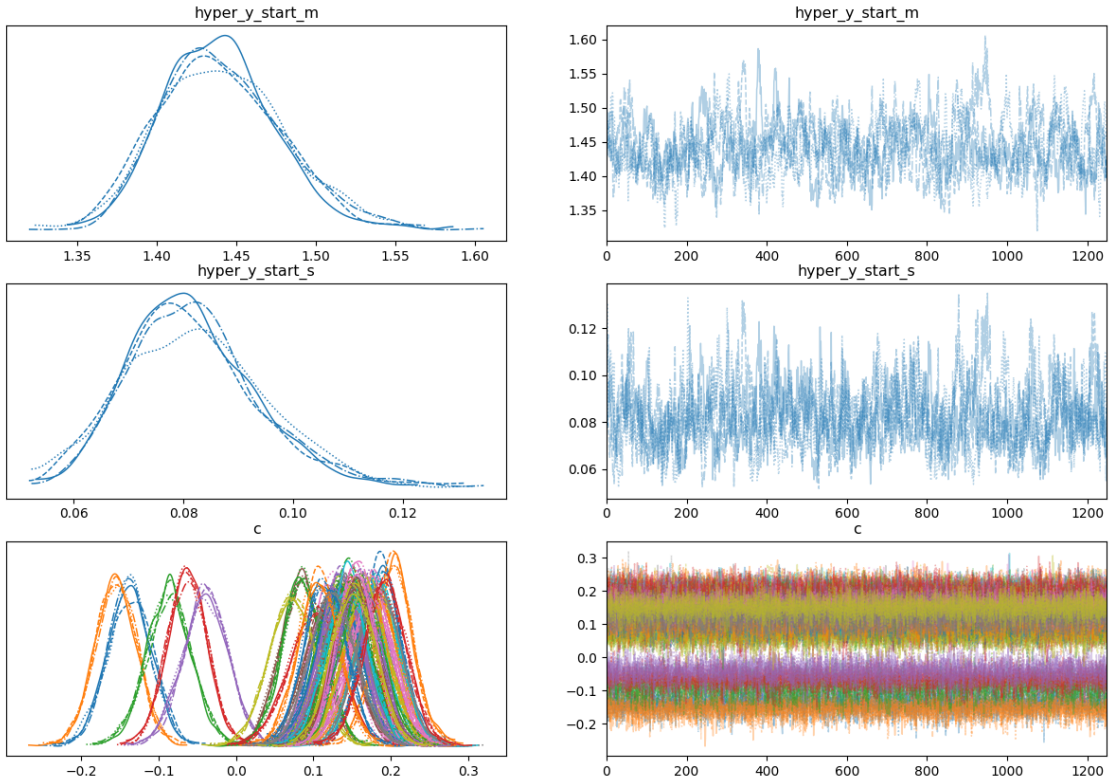
[8]:
```
plt_aux = az.plot_trace(ritorno['inference_data'],␣
↪var_names=['phi','theta','hyper_gamma_phi_m','hyper_gamma_phi_s'],␣
↪divergences=True, figsize=(15,15))
```



[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]	1.428	0.090	1.261	1.599	0.002	0.002	1424.0	2519.0	1.0
y_start[0, 1]	1.426	0.086	1.273	1.597	0.003	0.002	1028.0	2065.0	1.0
y_start[0, 2]	1.428	0.091	1.256	1.601	0.003	0.002	1207.0	1566.0	1.0
y_start[0, 3]	1.430	0.091	1.255	1.598	0.002	0.002	1439.0	1768.0	1.0
y_start[0, 4]	1.436	0.094	1.262	1.609	0.003	0.002	1339.0	1878.0	1.0
…	…	…	…	…	…	…	…	…	…
y_start[2, 44]	1.451	0.054	1.354	1.559	0.002	0.001	981.0		
y_start[2, 45]	1.447	0.056	1.342	1.551	0.002	0.001	888.0		
y_start[2, 46]	1.443	0.054	1.348	1.550	0.002	0.001	918.0		
y_start[2, 47]	1.459	0.056	1.357	1.567	0.002	0.001	826.0		
y_start[2, 48]	1.465	0.055	1.359	1.566	0.002	0.001	968.0		

```
y_start[2, 44]    1643.0    1.0
y_start[2, 45]    1248.0    1.0
y_start[2, 46]    1881.0    1.0
y_start[2, 47]    1179.0    1.0
y_start[2, 48]    1494.0    1.0

[147 rows x 9 columns]
```

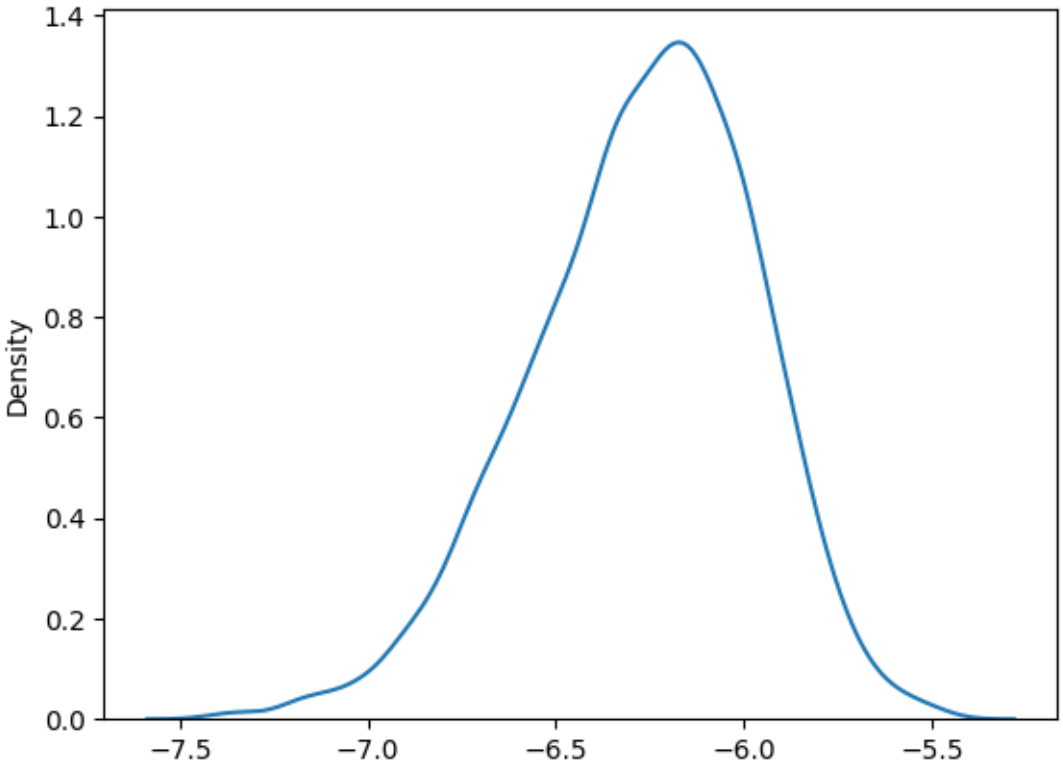
[12]:
```
az.summary(ritorno['inference_data'], var_names=['hyper_y_start_m',␣
 ↪'hyper_y_start_s'])
```

[12]:

	mean	sd	hdi_3%	hdi_97%	mcse_mean	mcse_sd	ess_bulk	ess_tail	r_hat
hyper_y_start_m	1.441	0.038	1.374	1.514	0.003	0.002	226.0	404.0	1.01
hyper_y_start_s	0.082	0.013	0.059	0.106	0.001	0.000	359.0	907.0	1.01

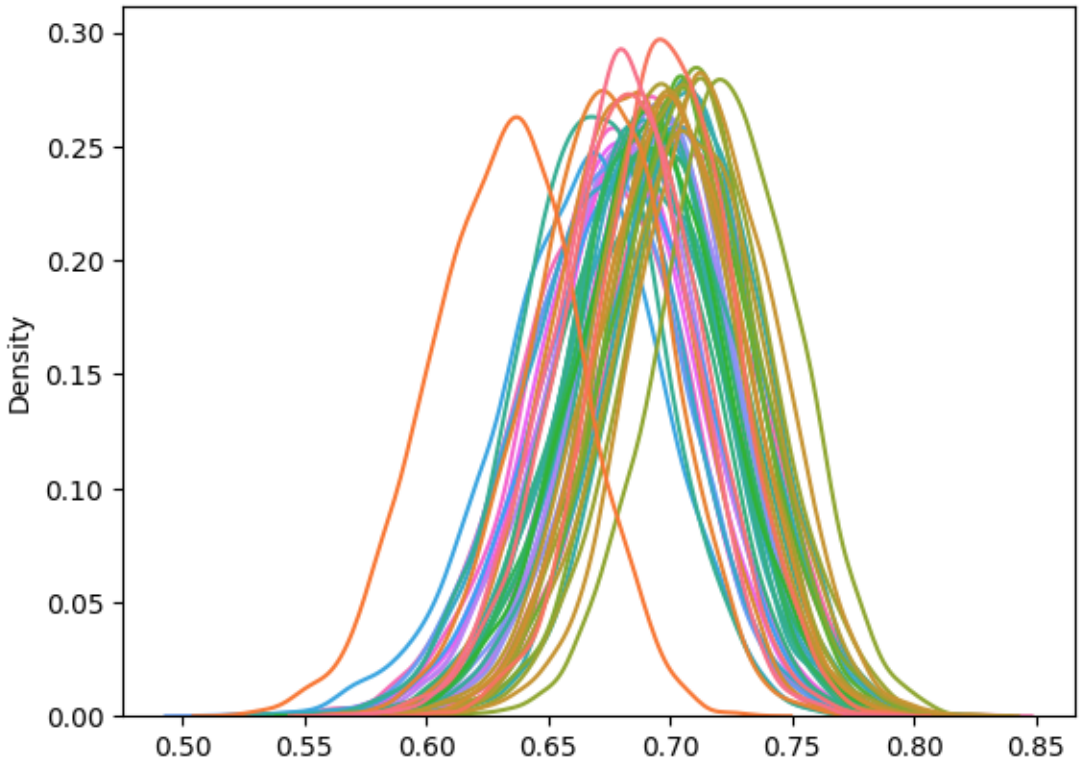
[13]:
```
aux_shape = ritorno['inference_data'].posterior.gamma_th.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.gamma_th.values.
 ↪reshape((aux_shape[0]*aux_shape[1])), legend=False)
```

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



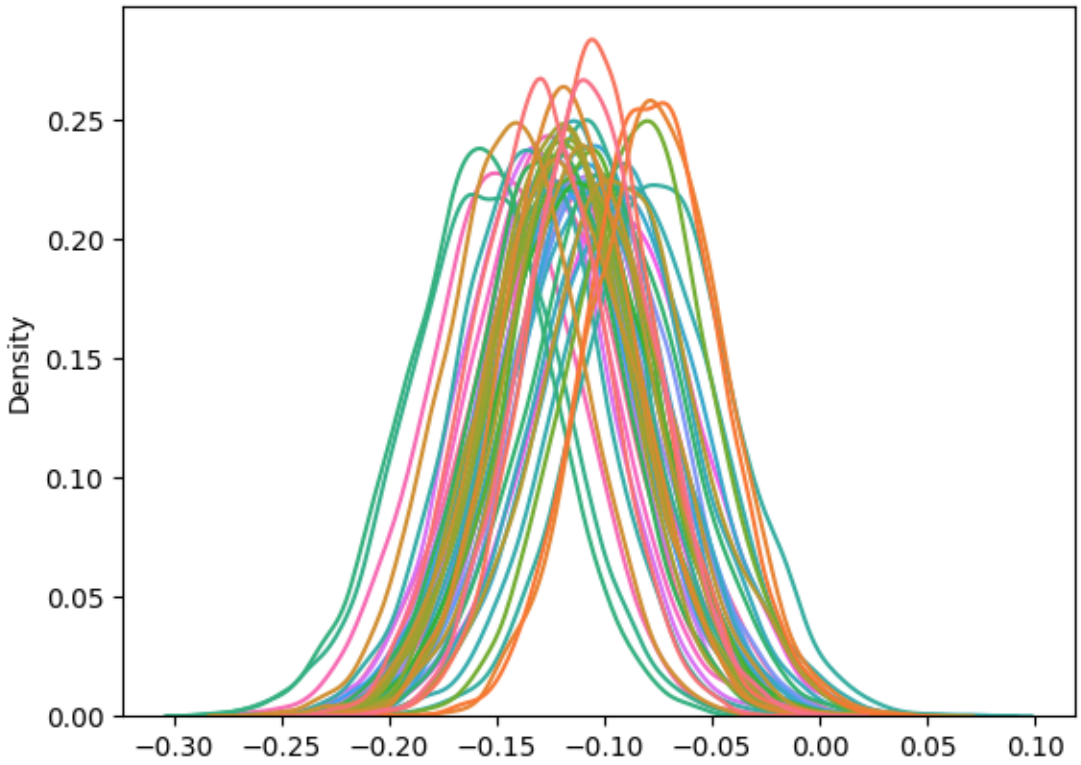
[14]:
```
aux_shape = ritorno['inference_data'].posterior.phi.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.phi.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2],aux_shape[3]))[:,0,:],␣
  ↪legend=False)
```

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



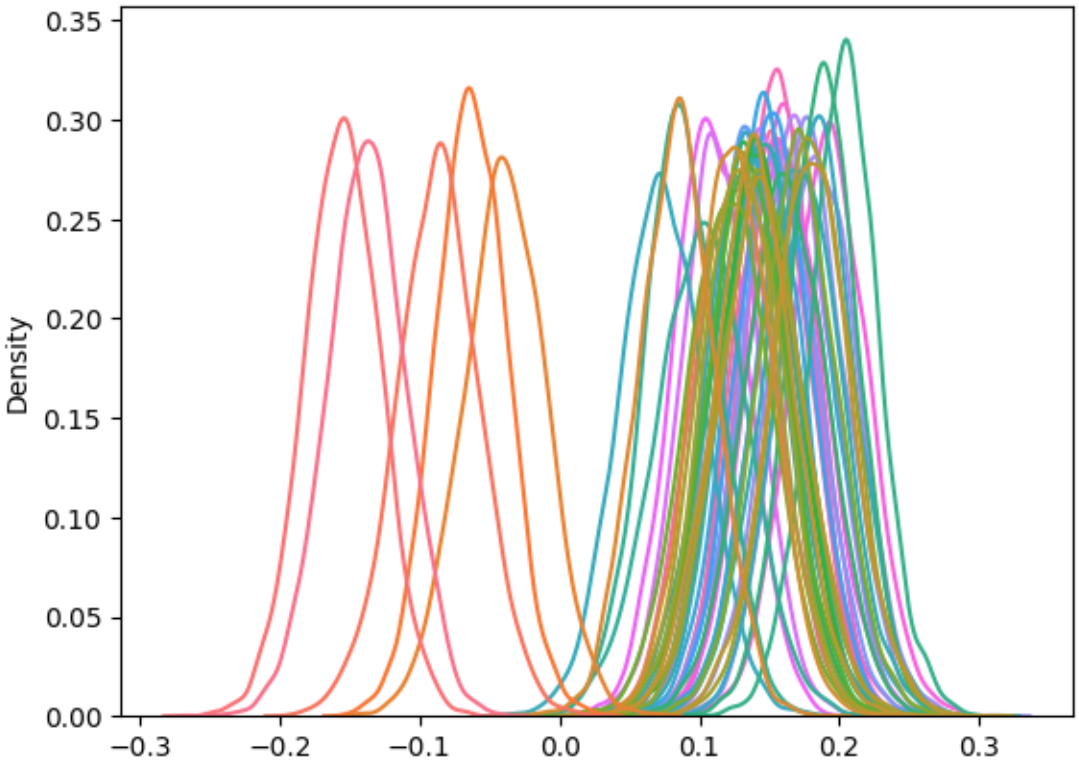
[15]:
```
aux_shape = ritorno['inference_data'].posterior.phi.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.phi.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2],aux_shape[3]))[:,1,:],␣
  ↪legend=False)
```

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



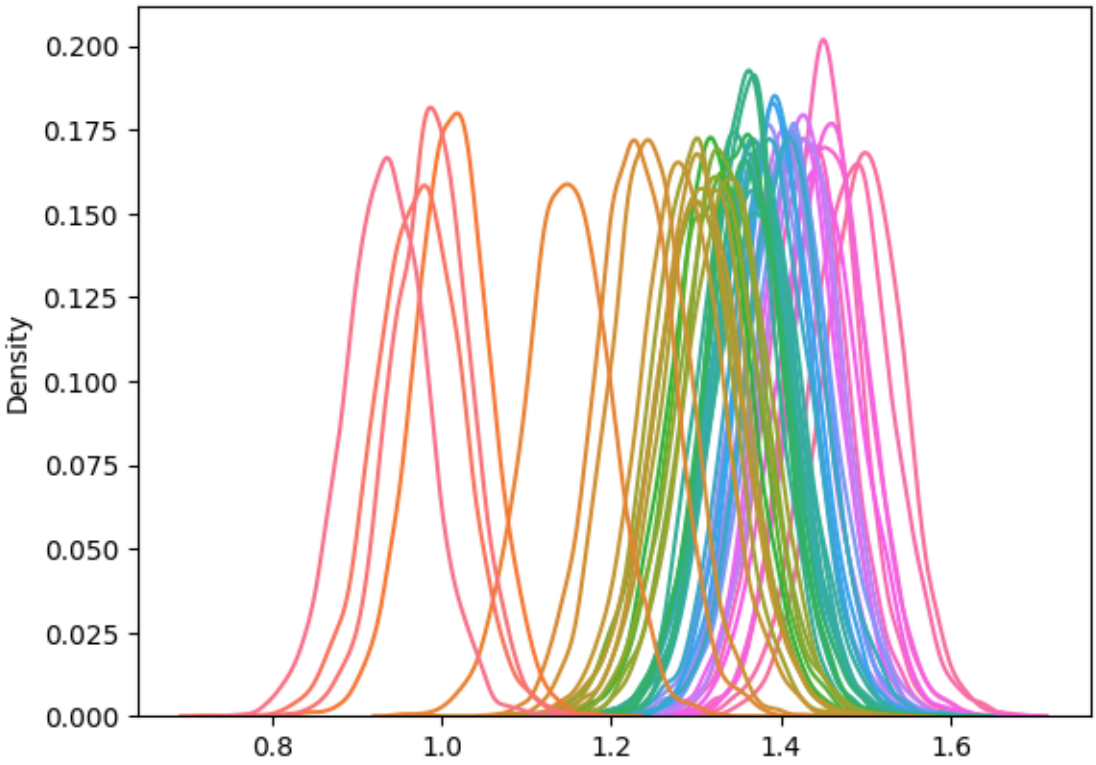
[16]:
```
aux_shape = ritorno['inference_data'].posterior.c.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.c.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

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



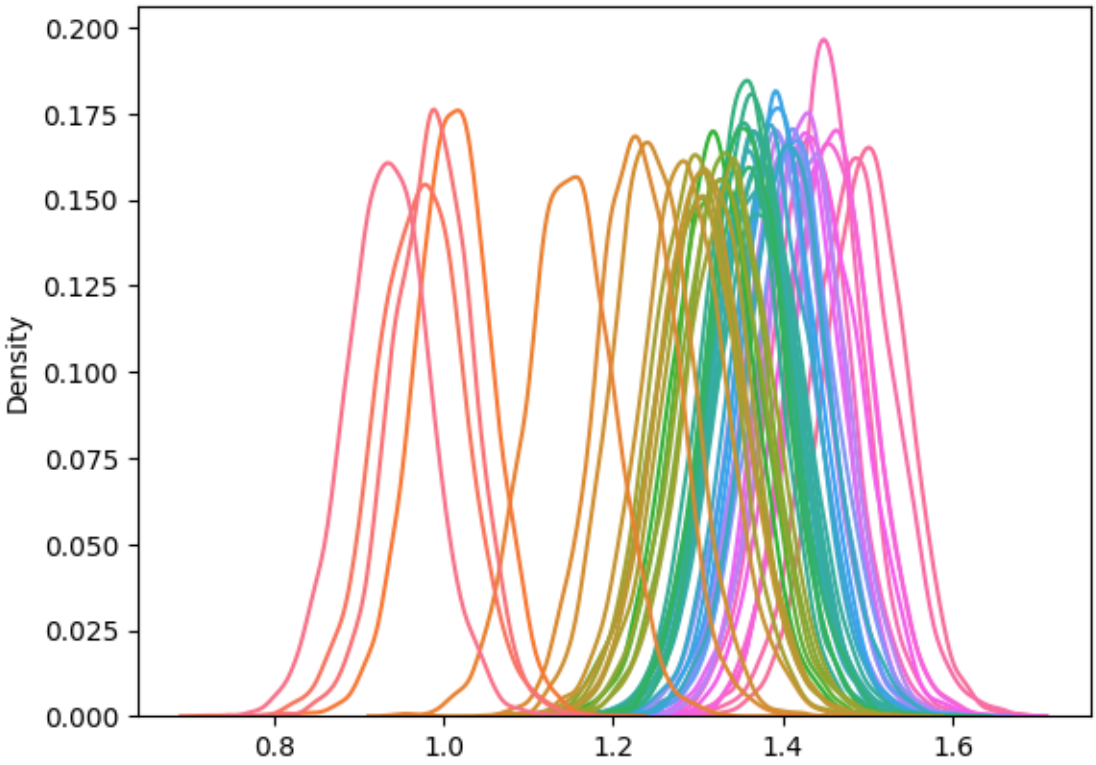
[17]:
```
aux_shape = ritorno['inference_data'].posterior.annual_mean.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_mean.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

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



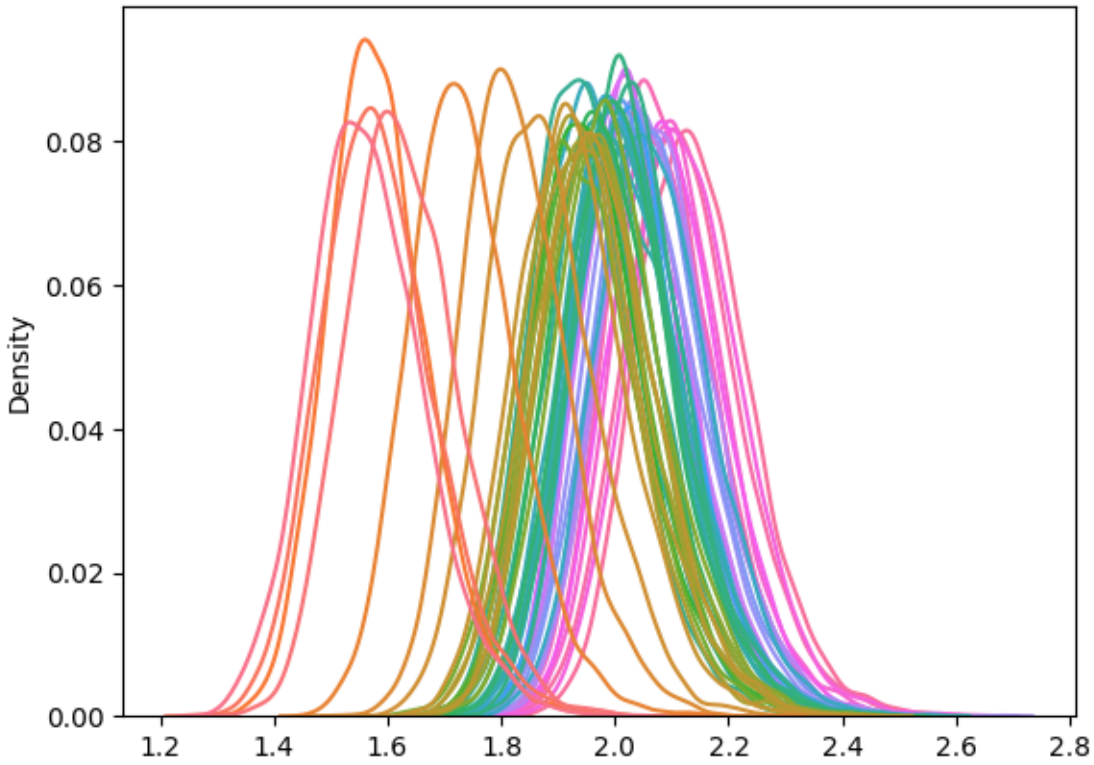
[18]:
```
aux_shape = ritorno['inference_data'].posterior.annual_median.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_median.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

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

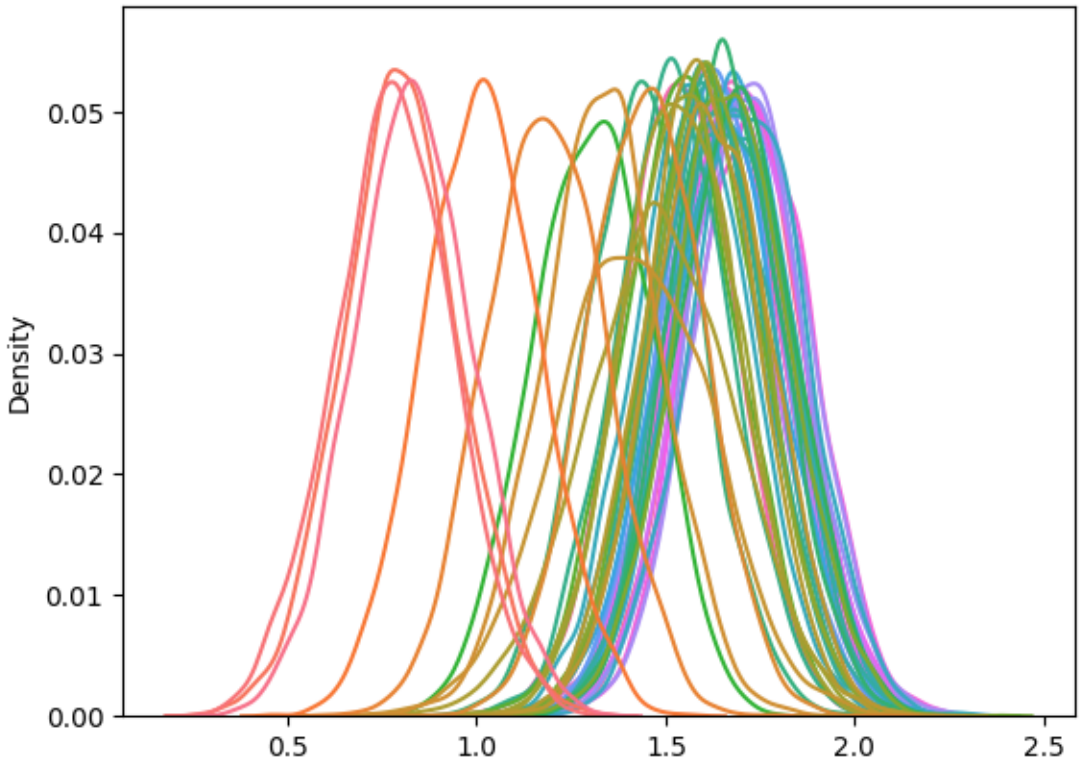


[19]:
```
aux_shape = ritorno['inference_data'].posterior.annual_max.values.shape
sns.kdeplot(ritorno['inference_data'].posterior.annual_max.values.
  ↪reshape((aux_shape[0]*aux_shape[1],aux_shape[2])), legend=False)
```

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

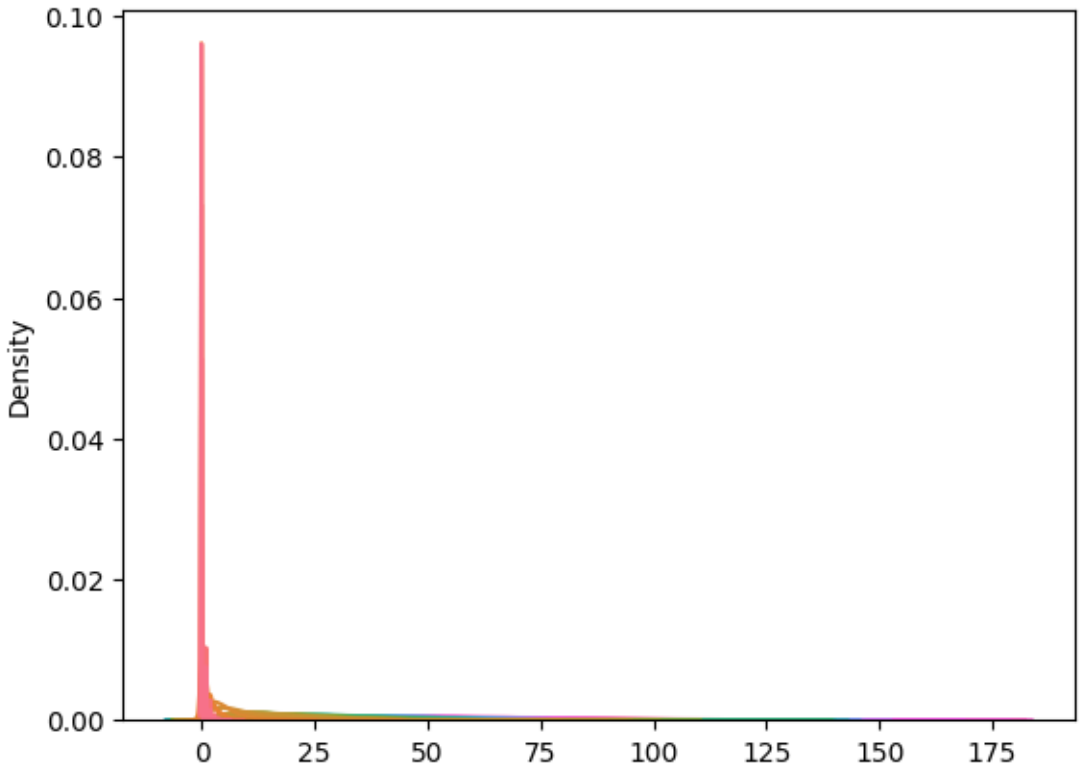


[20]:
```
valori_31_dic = []
for dizionario in ritorno['missing']:
    if dizionario['Data'] == '2018-12-31':
        valori_31_dic.append(dizionario['Samples'])

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	SAVIGNANO DI RIGO	CORTE BRUGNATELLA	FEBBIO	\
count	5000.000000	5000.000000	5000.000000	5000.000000	
mean	0.119200	0.130600	0.170800	0.306400	
std	0.422643	0.415184	0.533371	0.680156	
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	6.000000	6.000000	9.000000	6.000000	

	SAN LEO	VERUCCHIO	BADIA	GIARDINI MARGHERITA	\
count	5000.000000	5000.000000	5000.000000	5000.000000	
mean	1.583400	4.804800	7.843600	13.554000	
std	2.001861	3.975507	5.518299	8.352906	
min	0.000000	0.000000	0.000000	0.000000	

```
25%       0.000000     2.000000     4.000000            8.000000
50%       1.000000     4.000000     7.000000           12.000000
75%       2.000000     7.000000    11.000000           18.000000
max      24.000000    42.000000    42.000000           75.000000

       SAN PIETRO CAPOFIUME    MARECCHIA  PARCO BERTOZZI    LUGAGNANO  \
count          5000.000000  5000.000000     5000.000000  5000.000000
mean             15.655600    15.800600       17.107800    17.855200
std               9.705845     9.337059       10.243806     9.912491
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%              21.000000    20.250000       22.000000    23.000000
max              82.000000    90.000000       88.000000    83.000000

       DELTA CERVIA    DE AMICIS  SAN LAZZARO  PARCO RESISTENZA  \
count   5000.000000  5000.000000  5000.000000        5000.00000
mean      17.867400    17.951600    18.928600          19.46160
std        9.684223     9.433147    10.543004          10.36772
min        0.000000     0.000000     0.000000           0.00000
25%       11.000000    11.000000    11.000000          12.00000
50%       16.000000    16.000000    17.000000          18.00000
75%       23.000000    23.000000    24.000000          25.00000
max       92.000000    78.000000    86.000000          84.00000

       FRANCHINI-ANGELONI     GHERARDI  VIA CHIARINI    SAVIGNANO  \
count         5000.000000  5000.000000   5000.000000  5000.000000
mean            21.112200    21.216200     21.463000    23.671600
std             11.518565    11.860742     11.379584    11.679479
min              0.000000     0.000000      1.000000     0.000000
25%             13.000000    13.000000     13.000000    15.000000
50%             19.000000    19.000000     20.000000    22.000000
75%             27.000000    27.000000     27.000000    30.000000
max            104.000000   121.000000     95.000000    90.000000

           GAVELLO    BESENZONE  VILLA FULVIA         ROMA  PORTA SAN FELICE  \
count  5000.000000  5000.000000   5000.000000  5000.000000       5000.000000
mean     23.673800    24.549600     28.082400    28.478600         29.057200
std      11.559901    13.067857     13.089594    13.462979         13.000359
min       1.000000     0.000000      1.000000     1.000000          1.000000
25%      15.000000    15.000000     19.000000    19.000000         20.000000
50%      22.000000    22.000000     26.000000    27.000000         27.000000
75%      30.000000    31.000000     35.000000    36.000000         37.000000
max      93.000000    95.000000    101.000000   132.000000        129.000000

            CAORLE  CASTELLARANO  PARCO MONTECUCCO    ZALAMELLA        CENTO  \
count  5000.000000   5000.000000       5000.000000  5000.000000  5000.000000
```

mean	29.496600	29.690800	30.348400	30.654000	30.750400
std	14.558213	12.144146	14.083433	14.440166	14.005246
min	1.000000	1.000000	0.000000	0.000000	0.000000
25%	19.000000	21.000000	20.000000	20.000000	21.000000
50%	27.000000	28.000000	28.000000	29.000000	29.000000
75%	38.000000	37.000000	38.000000	39.000000	39.000000
max	132.000000	95.000000	113.000000	135.000000	110.000000

	PARCO EDILCARANI	BOGOLESE	SARAGAT	PARADIGNA	MALCANTONE \
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.00000
mean	31.862400	32.414000	34.823600	36.049800	36.40740
std	12.495227	14.122114	14.769946	15.517109	15.62687
min	3.000000	3.000000	1.000000	1.000000	3.00000
25%	23.000000	22.000000	24.000000	25.000000	25.00000
50%	30.000000	30.000000	33.000000	34.000000	34.00000
75%	39.000000	41.000000	44.000000	45.000000	45.00000
max	97.000000	126.000000	106.000000	137.000000	144.00000

	S. LAZZARO	REMESINA	S. ROCCO	CENO	ISONZO \
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000
mean	36.717600	37.258400	38.640600	41.682000	42.197200
std	15.295524	15.270752	15.793585	16.954432	16.223247
min	2.000000	3.000000	3.000000	3.000000	3.000000
25%	26.000000	26.000000	27.000000	30.000000	30.000000
50%	35.000000	35.000000	37.000000	40.000000	41.000000
75%	46.000000	46.000000	48.000000	51.250000	52.000000
max	144.000000	117.000000	126.000000	132.000000	124.000000

	PARCO FERRARI	CITTADELLA	GIORDANI-FARNESE	SAN FRANCESCO \
count	5000.000000	5000.000000	5000.000000	5000.000000
mean	42.662200	46.169400	46.499200	50.950200
std	16.549878	17.223322	17.256279	17.201375
min	5.000000	6.000000	5.000000	8.000000
25%	31.000000	34.000000	34.000000	39.000000
50%	41.000000	45.000000	45.000000	49.000000
75%	52.000000	56.000000	57.000000	61.000000
max	131.000000	137.000000	137.000000	157.000000

	FLAMINIA	MONTEBELLO	GIARDINI	GERBIDO	TIMAVO
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000
mean	51.843400	55.108200	60.897800	63.058000	70.958800
std	19.372205	19.523666	19.522161	22.329388	22.126125
min	6.000000	7.000000	11.000000	8.000000	8.000000
25%	38.000000	42.000000	47.000000	47.000000	55.000000
50%	50.000000	53.000000	59.000000	61.000000	69.000000
75%	63.000000	67.000000	73.000000	76.000000	85.000000
max	158.000000	173.000000	168.000000	170.000000	170.000000

[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	5000.0	5000.0	5000.0	5000.0	5000.0
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	5000.000000	5000.00000	5000.000000	5000.000000
mean	0.000400	0.00100	0.022600	0.038200
std	0.019998	0.03161	0.148639	0.191698
min	0.000000	0.00000	0.000000	0.000000
25%	0.000000	0.00000	0.000000	0.000000
50%	0.000000	0.00000	0.000000	0.000000
75%	0.000000	0.00000	0.000000	0.000000
max	1.000000	1.00000	1.000000	1.000000

	SAN PIETRO CAPOFIUME	DE AMICIS	DELTA CERVIA	LUGAGNANO
count	5000.000000	5000.000000	5000.000000	5000.000000
mean	0.043400	0.051800	0.052600	0.056000
std	0.203776	0.221645	0.223256	0.229945
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

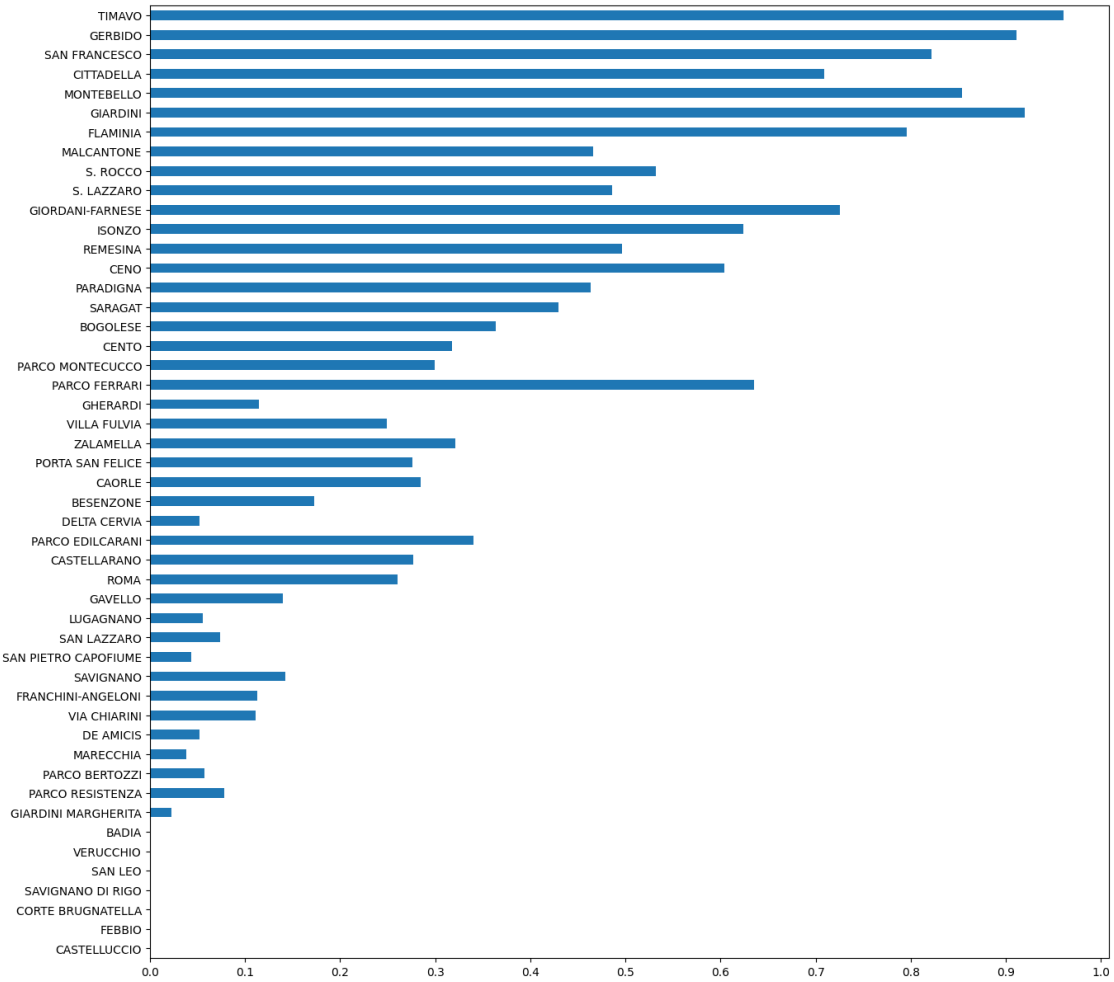
	PARCO BERTOZZI	SAN LAZZARO	PARCO RESISTENZA	VIA CHIARINI
count	5000.000000	5000.000000	5000.000000	5000.000000
mean	0.057200	0.074000	0.078400	0.111200
std	0.232248	0.261797	0.268827	0.314411
min	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000	0.000000
50%	0.000000	0.000000	0.000000	0.000000
75%	0.000000	0.000000	0.000000	0.000000
max	1.000000	1.000000	1.000000	1.000000

```
       FRANCHINI-ANGELONI     GHERARDI      GAVELLO    SAVIGNANO    BESENZONE  \
count         5000.000000  5000.000000  5000.000000  5000.000000  5000.000000
mean             0.113000     0.114800     0.140000     0.142600     0.173200
std              0.316624     0.318812     0.347022     0.349699     0.378458
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

       VILLA FULVIA         ROMA  PORTA SAN FELICE  CASTELLARANO      CAORLE  \
count   5000.000000  5000.000000       5000.000000   5000.000000  5000.00000
mean       0.248800     0.260400          0.276000      0.276800     0.28500
std        0.432361     0.438897          0.447061      0.447462     0.45146
min        0.000000     0.000000          0.000000      0.000000     0.00000
25%        0.000000     0.000000          0.000000      0.000000     0.00000
50%        0.000000     0.000000          0.000000      0.000000     0.00000
75%        0.000000     1.000000          1.000000      1.000000     1.00000
max        1.000000     1.000000          1.000000      1.000000     1.00000

       PARCO MONTECUCCO        CENTO    ZALAMELLA  PARCO EDILCARANI  \
count       5000.000000  5000.000000  5000.000000       5000.000000
mean           0.299800     0.317400     0.320800          0.340400
std            0.458216     0.465511     0.466831          0.473891
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

          BOGOLESE     SARAGAT    PARADIGNA  MALCANTONE   S. LAZZARO  \
count  5000.000000  5000.00000  5000.000000  5000.00000  5000.000000
mean      0.363400     0.42940     0.463600     0.46640     0.485800
std       0.481027     0.49504     0.498723     0.49892     0.499848
min       0.000000     0.00000     0.000000     0.00000     0.000000
25%       0.000000     0.00000     0.000000     0.00000     0.000000
50%       0.000000     0.00000     0.000000     0.00000     0.000000
75%       1.000000     1.00000     1.000000     1.00000     1.000000
max       1.000000     1.00000     1.000000     1.00000     1.000000

          REMESINA     S. ROCCO         CENO       ISONZO  PARCO FERRARI  \
count  5000.000000  5000.000000  5000.000000  5000.000000    5000.000000
mean      0.496000     0.531800     0.604000     0.624000       0.635000
std       0.500034     0.499038     0.489113     0.484428       0.481478
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     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

        CITTADELLA  GIORDANI-FARNESE     FLAMINIA  SAN FRANCESCO   MONTEBELLO  \
count  5000.000000       5000.000000  5000.000000    5000.000000  5000.000000
mean      0.709200          0.725200     0.796000       0.821600     0.853600
std       0.454177          0.446458     0.403009       0.382887     0.353542
min       0.000000          0.000000     0.000000       0.000000     0.000000
25%       0.000000          0.000000     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

           GERBIDO    GIARDINI       TIMAVO
count  5000.000000  5000.00000  5000.000000
mean      0.910800     0.92000     0.960600
std       0.285061     0.27132     0.194564
min       0.000000     0.00000     0.000000
25%       1.000000     1.00000     1.000000
50%       1.000000     1.00000     1.000000
75%       1.000000     1.00000     1.000000
max       1.000000     1.00000     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	BOGOLESE	CENTO	PARCO MONTECUCCO	PARCO FERRARI	\
count	5000.0	5000.0	5000.0	5000.0	5000.0	
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	

	VILLA FULVIA	ZALAMELLA	PORTA SAN FELICE	S. LAZZARO	BESENZONE	\
count	5000.0	5000.0	5000.0	5000.0	5000.0	
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	

	DELTA CERVIA	PARCO EDILCARANI	CASTELLARANO	GAVELLO	SARAGAT	\
count	5000.0	5000.0	5000.0	5000.0	5000.0	
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 LAZZARO	LUGAGNANO	SAVIGNANO	FEBBIO	CORTE BRUGNATELLA	\
count	5000.0	5000.0	5000.0	5000.0	5000.0	
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	

	SAVIGNANO DI RIGO	SAN LEO	VERUCCHIO	BADIA	SAN PIETRO CAPOFIUME	\
count	5000.0	5000.0	5000.0	5000.0	5000.0	
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	

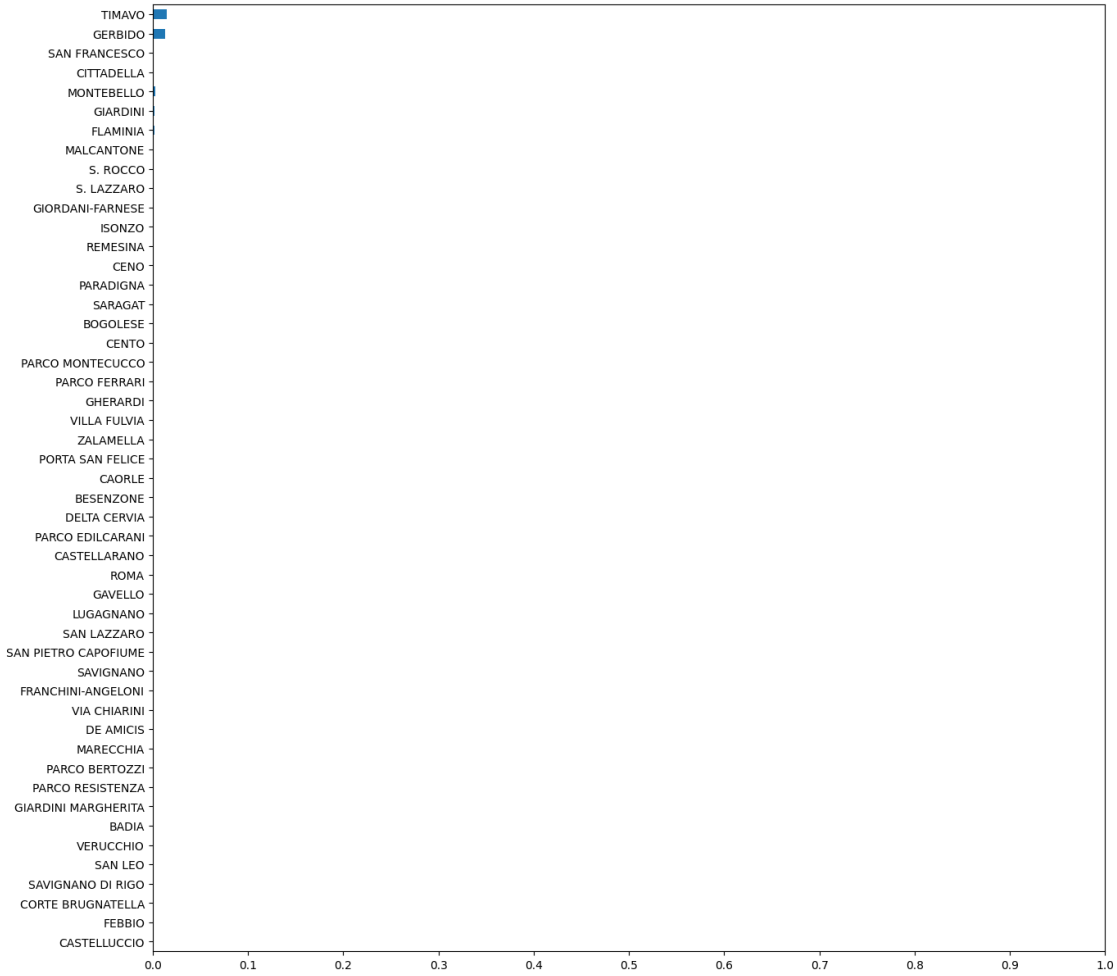
	GIARDINI MARGHERITA	PARCO BERTOZZI	MARECCHIA	DE AMICIS	\
count	5000.0	5000.0	5000.0	5000.0	
mean	0.0	0.0	0.0	0.0	
std	0.0	0.0	0.0	0.0	
min	0.0	0.0	0.0	0.0	
25%	0.0	0.0	0.0	0.0	

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

       VIA CHIARINI  FRANCHINI-ANGELONI  PARCO RESISTENZA  REMESINA  \
count        5000.0              5000.0            5000.0    5000.0
mean            0.0                 0.0               0.0       0.0
std             0.0                 0.0               0.0       0.0
min             0.0                 0.0               0.0       0.0
25%             0.0                 0.0               0.0       0.0
50%             0.0                 0.0               0.0       0.0
75%             0.0                 0.0               0.0       0.0
max             0.0                 0.0               0.0       0.0

            ISONZO     S. ROCCO       CAORLE    PARADIGNA     GHERARDI  \
count  5000.000000  5000.000000  5000.000000  5000.000000  5000.000000
mean      0.000200     0.000200     0.000200     0.000200     0.000200
std       0.014142     0.014142     0.014142     0.014142     0.014142
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         CENO  GIORDANI-FARNESE  MALCANTONE  CITTADELLA  \
count  5000.000000  5000.000000        5000.00000  5000.00000  5000.00000
mean      0.000200     0.000400           0.00060     0.00060     0.00060
std       0.014142     0.019998           0.02449     0.02449     0.02449
min       0.000000     0.000000           0.00000     0.00000     0.00000
25%       0.000000     0.000000           0.00000     0.00000     0.00000
50%       0.000000     0.000000           0.00000     0.00000     0.00000
75%       0.000000     0.000000           0.00000     0.00000     0.00000
max       1.000000     1.000000           1.00000     1.00000     1.00000

       SAN FRANCESCO     GIARDINI     FLAMINIA   MONTEBELLO      GERBIDO  \
count     5000.00000  5000.000000  5000.000000  5000.000000  5000.000000
mean         0.00100     0.001800     0.002200     0.002600     0.013400
std          0.03161     0.042392     0.046857     0.050929     0.114992
min          0.00000     0.000000     0.000000     0.000000     0.000000
25%          0.00000     0.000000     0.000000     0.000000     0.000000
50%          0.00000     0.000000     0.000000     0.000000     0.000000
75%          0.00000     0.000000     0.000000     0.000000     0.000000
max          1.00000     1.000000     1.000000     1.000000     1.000000

            TIMAVO
count  5000.000000
mean      0.014600
```

```
std       0.119957
min       0.000000
25%       0.000000
50%       0.000000
75%       0.000000
max       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]: (5000, 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()
```

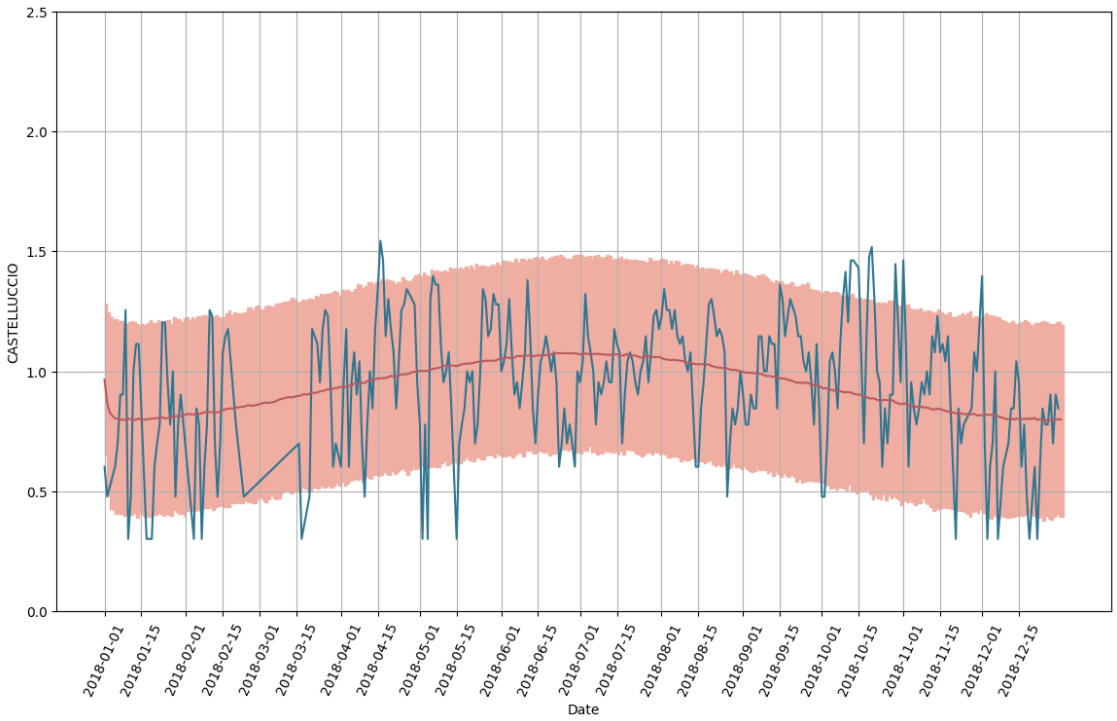
```
interactive(children=(Dropdown(description='stazione', options=('CASTELLUCCIO',␣
 ↪'FEBBIO', 'CORTE BRUGNATELLA',…
```

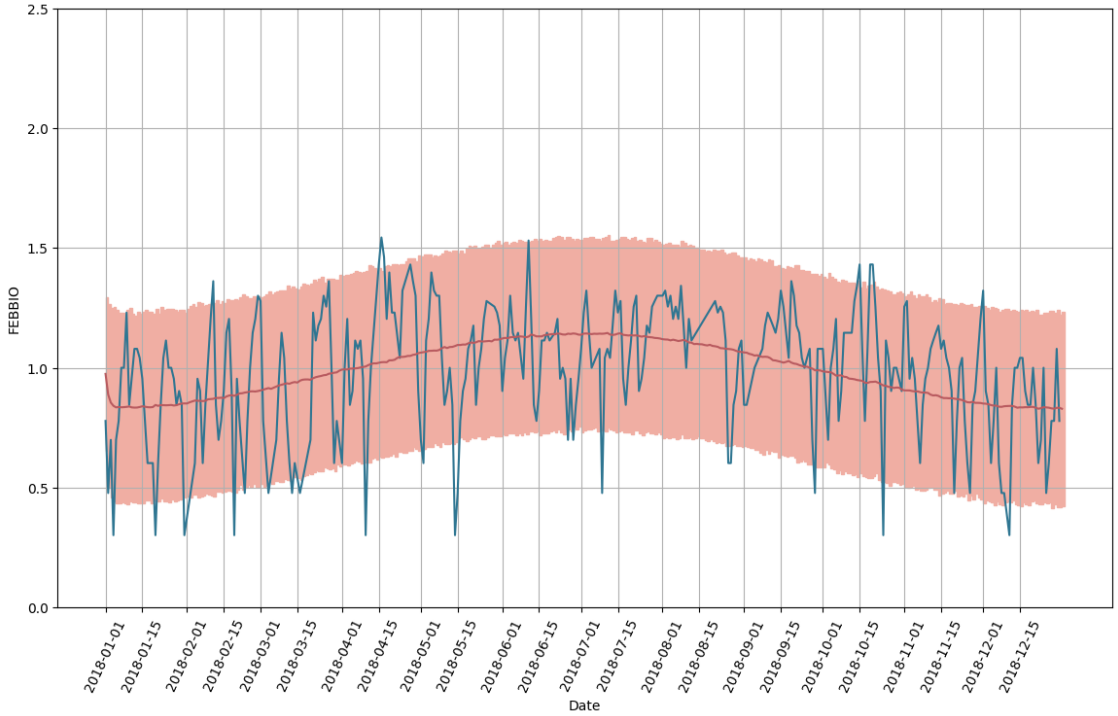
[30]:
```
def f(stazione):
    col_map = sns.light_palette((20, 75, 70), input='husl', as_cmap=True)

    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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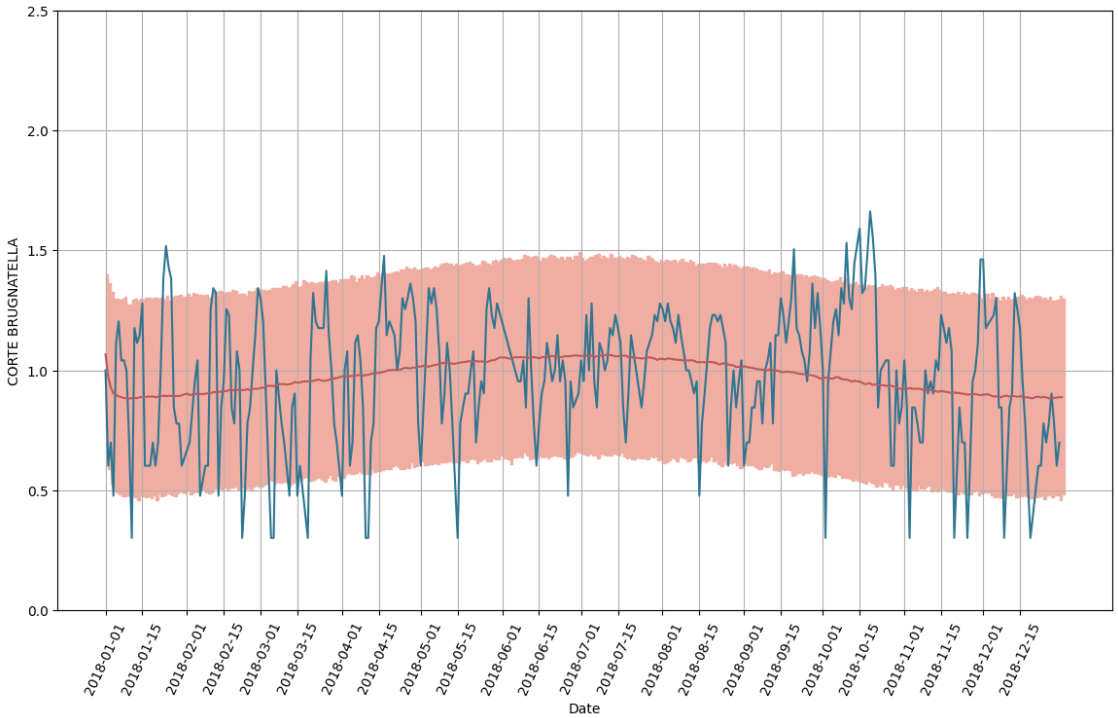
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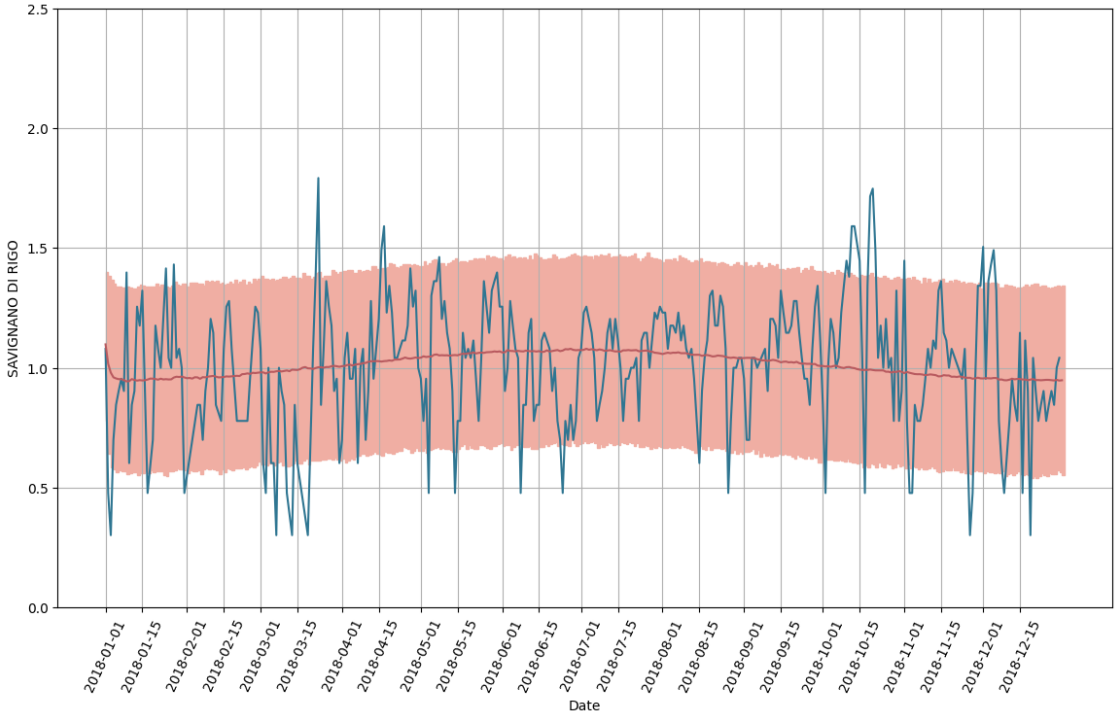
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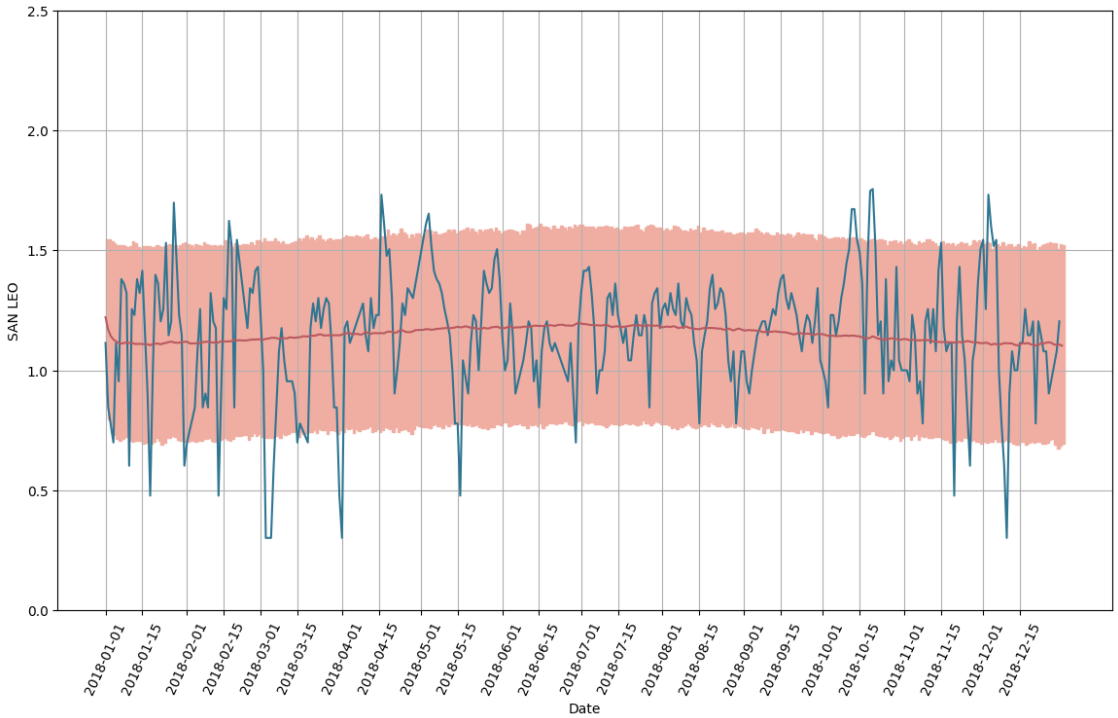
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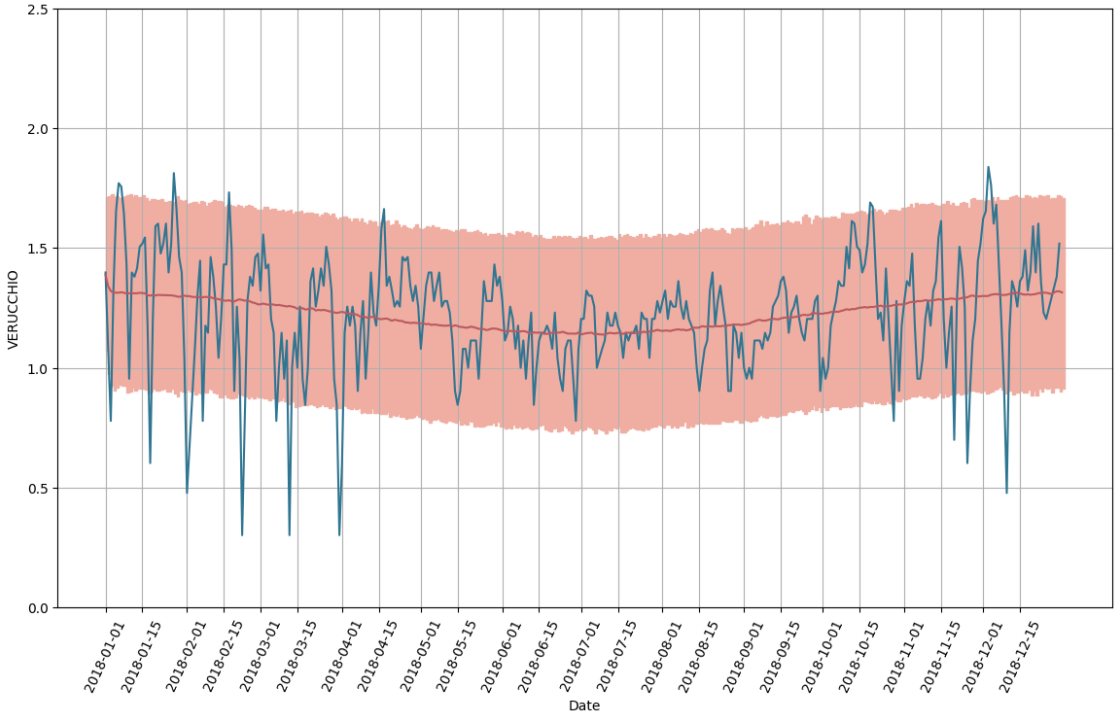
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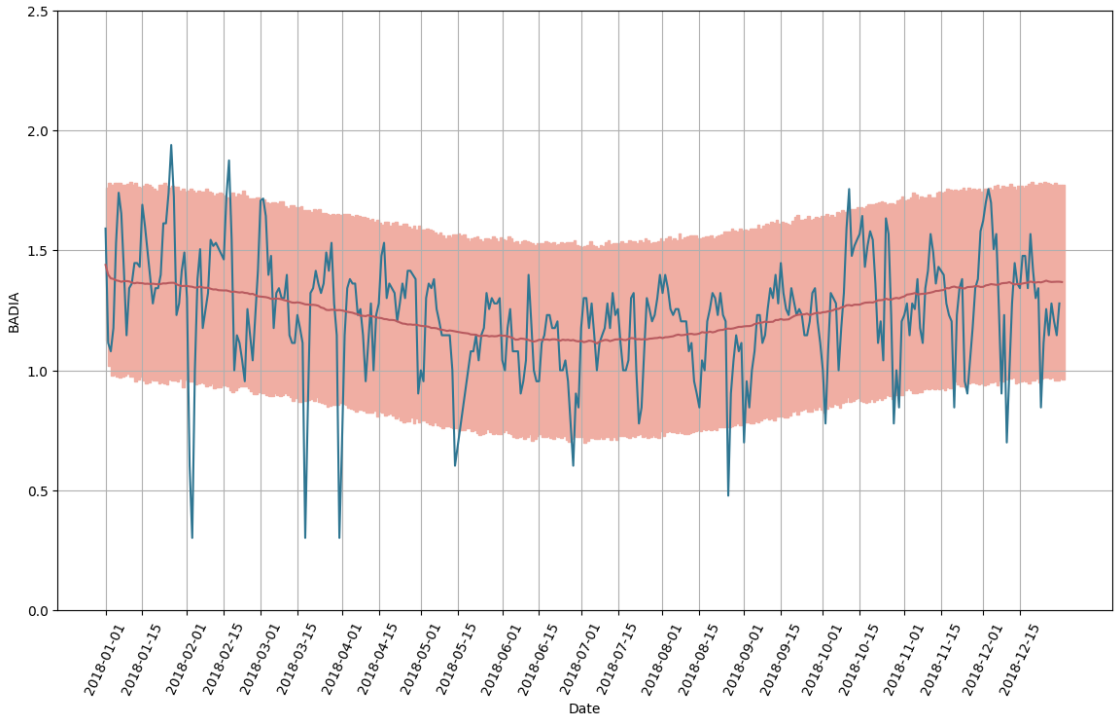
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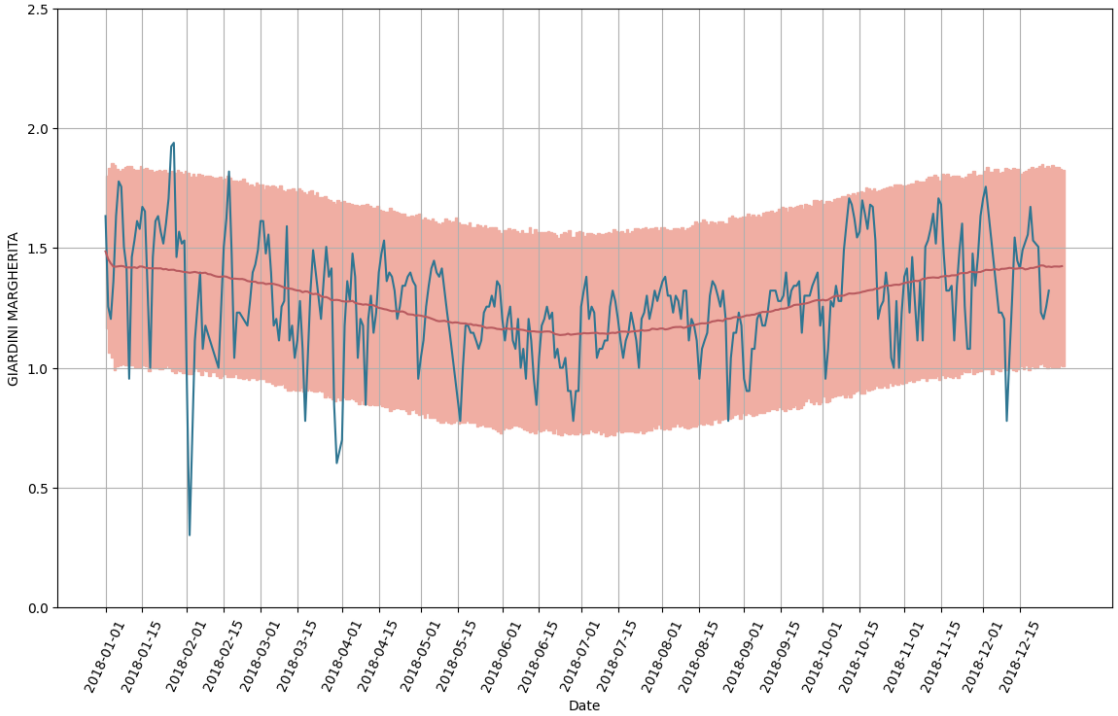
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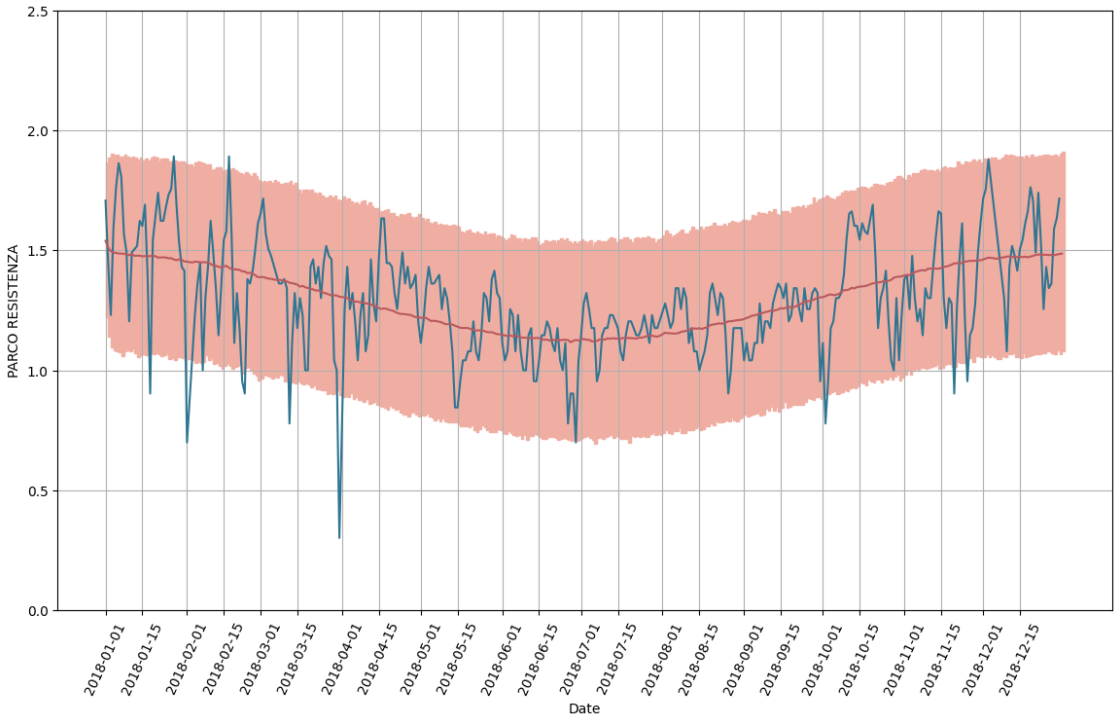
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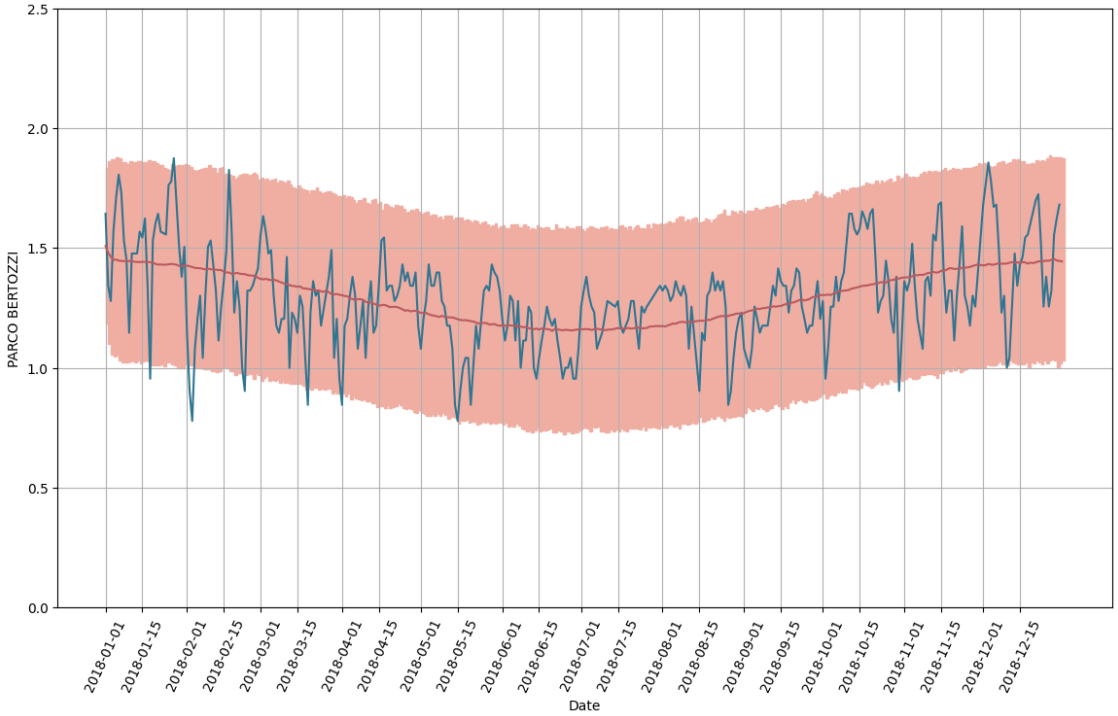
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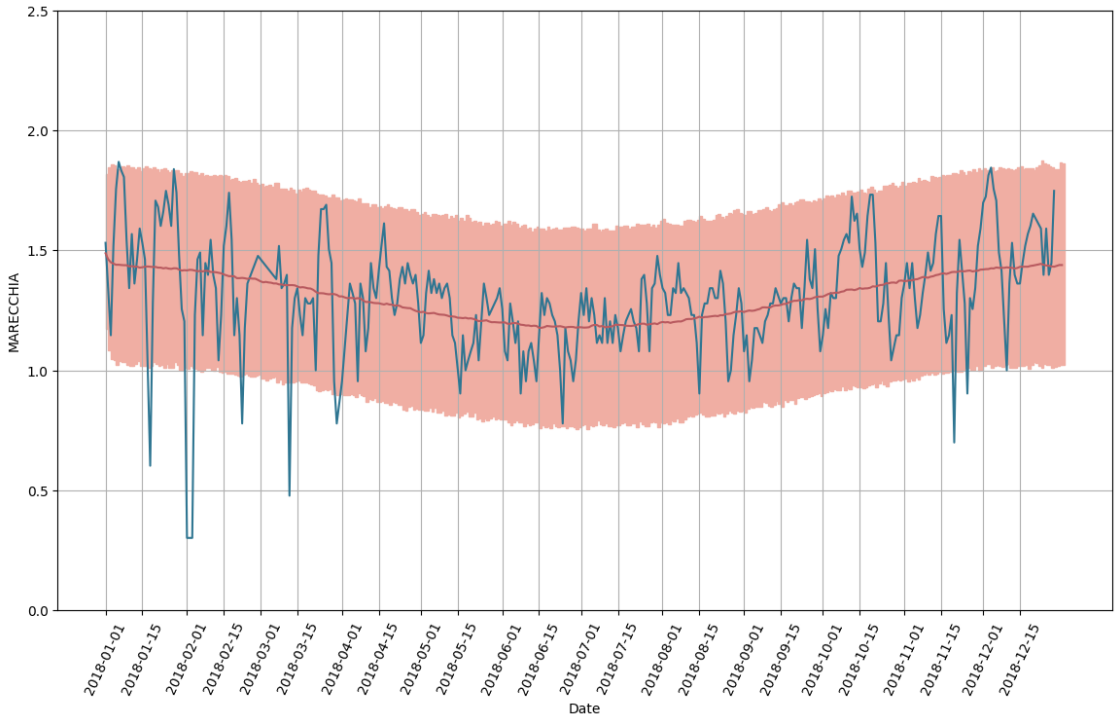
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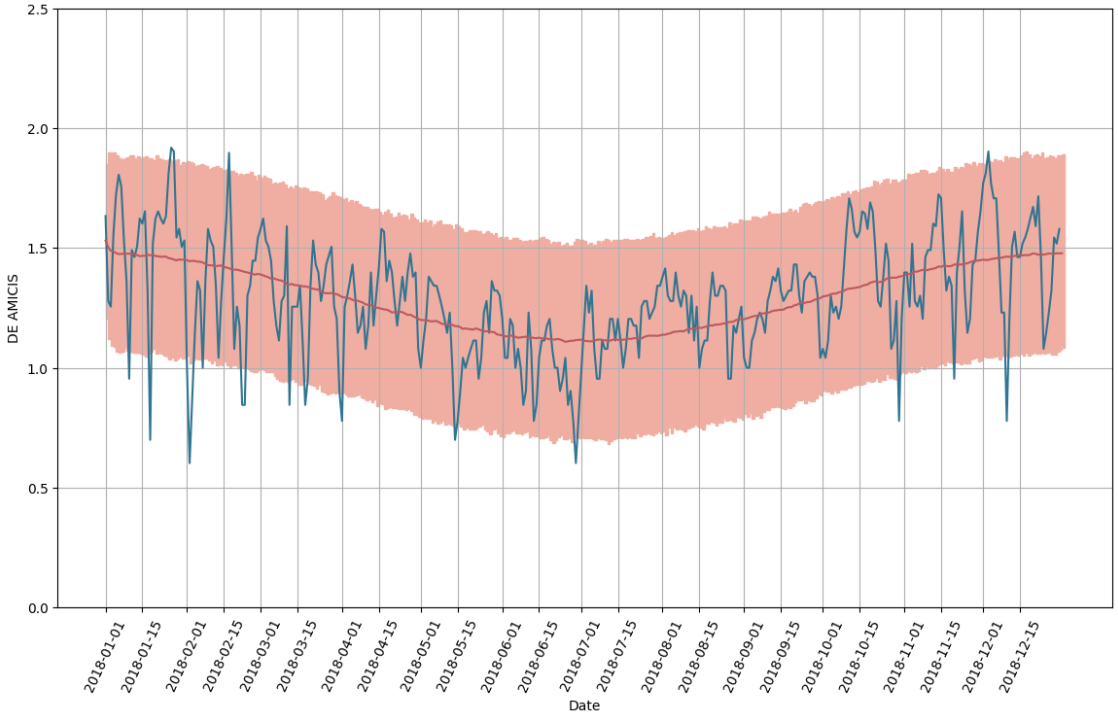
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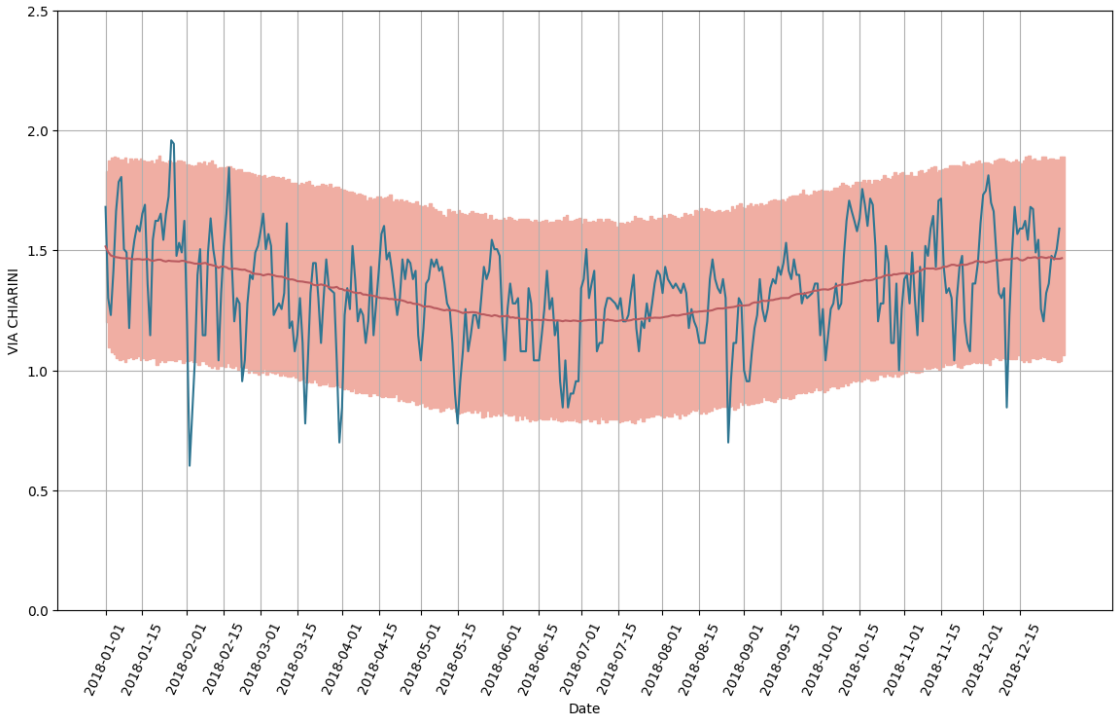
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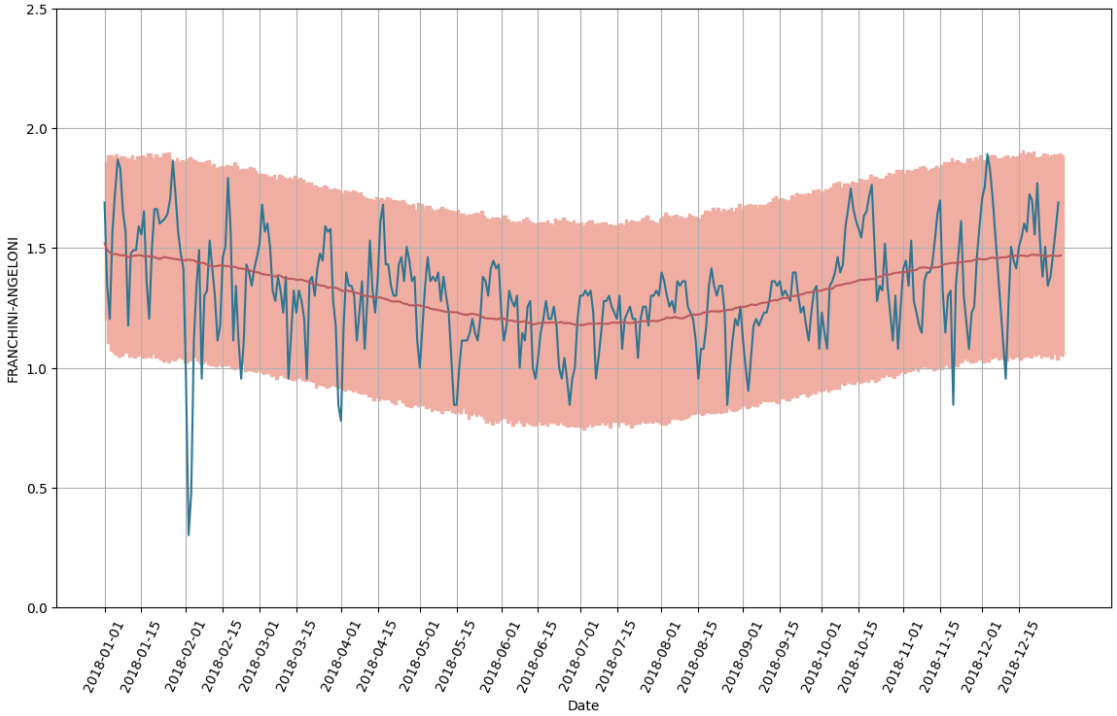
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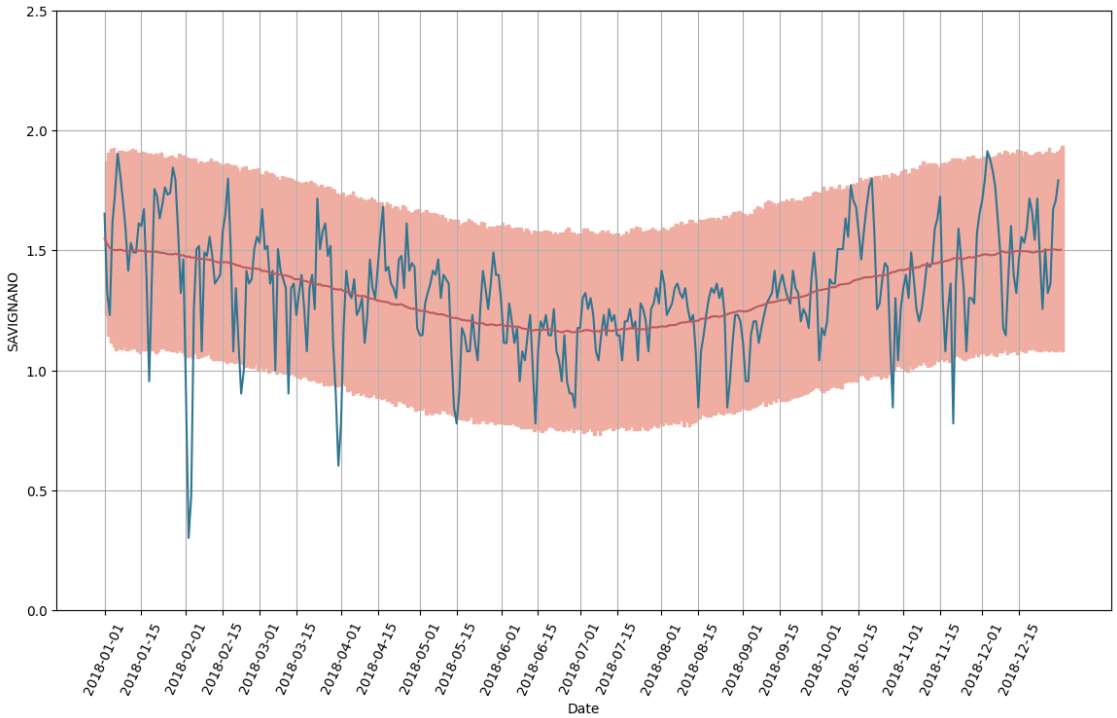
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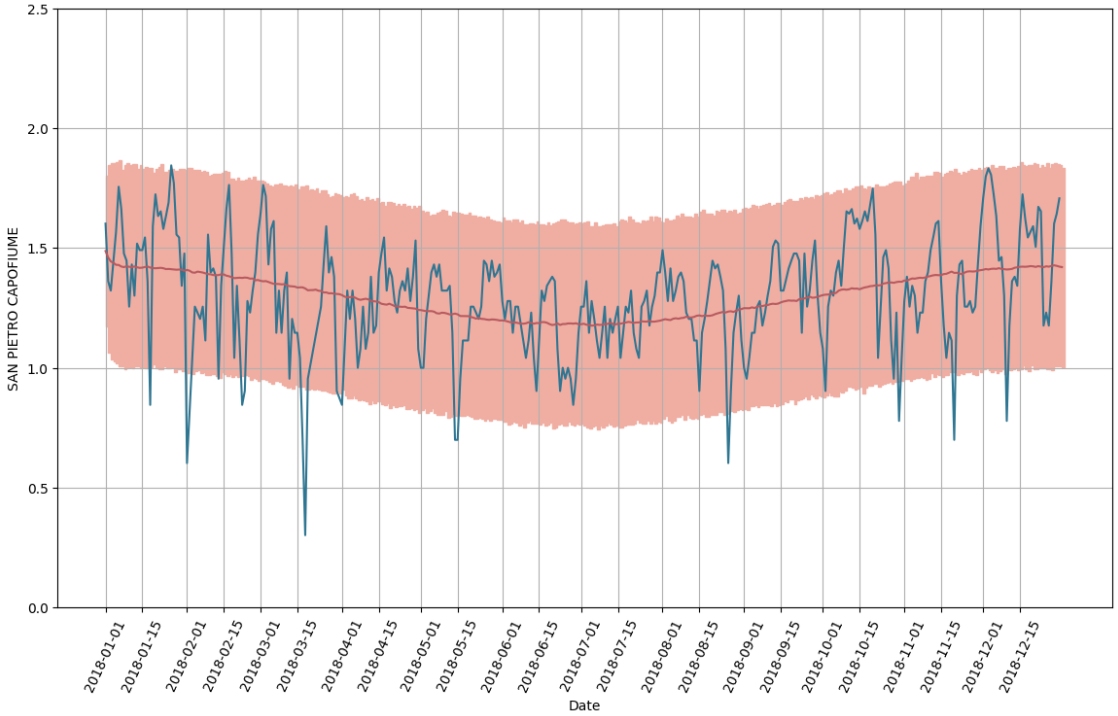
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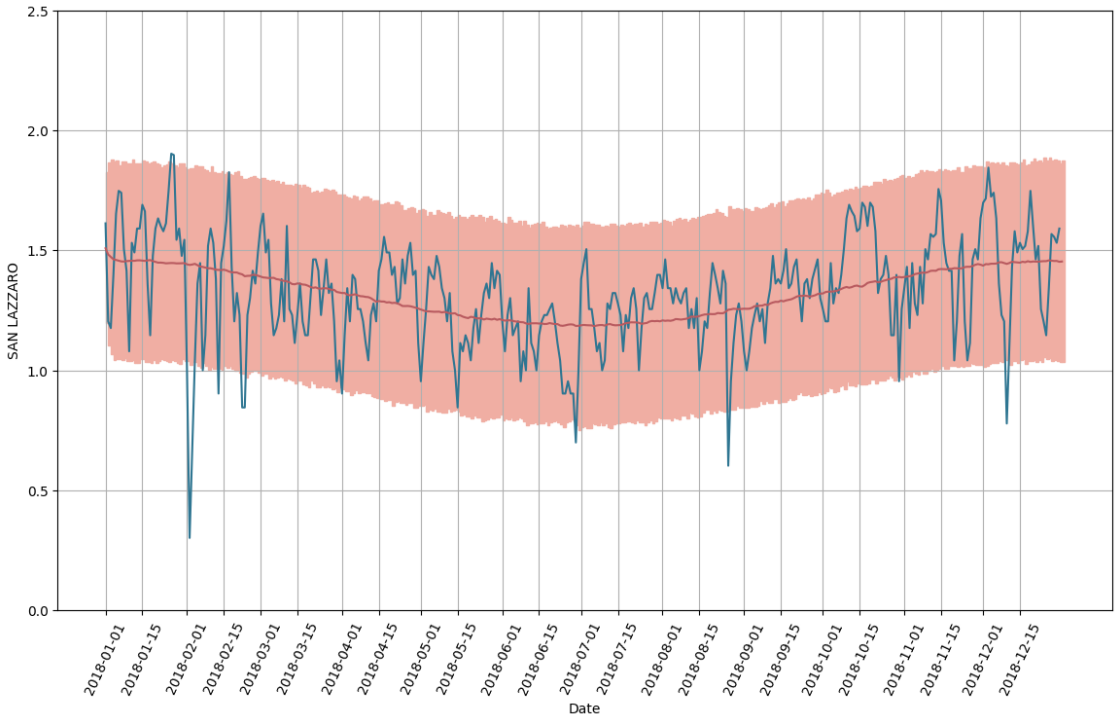
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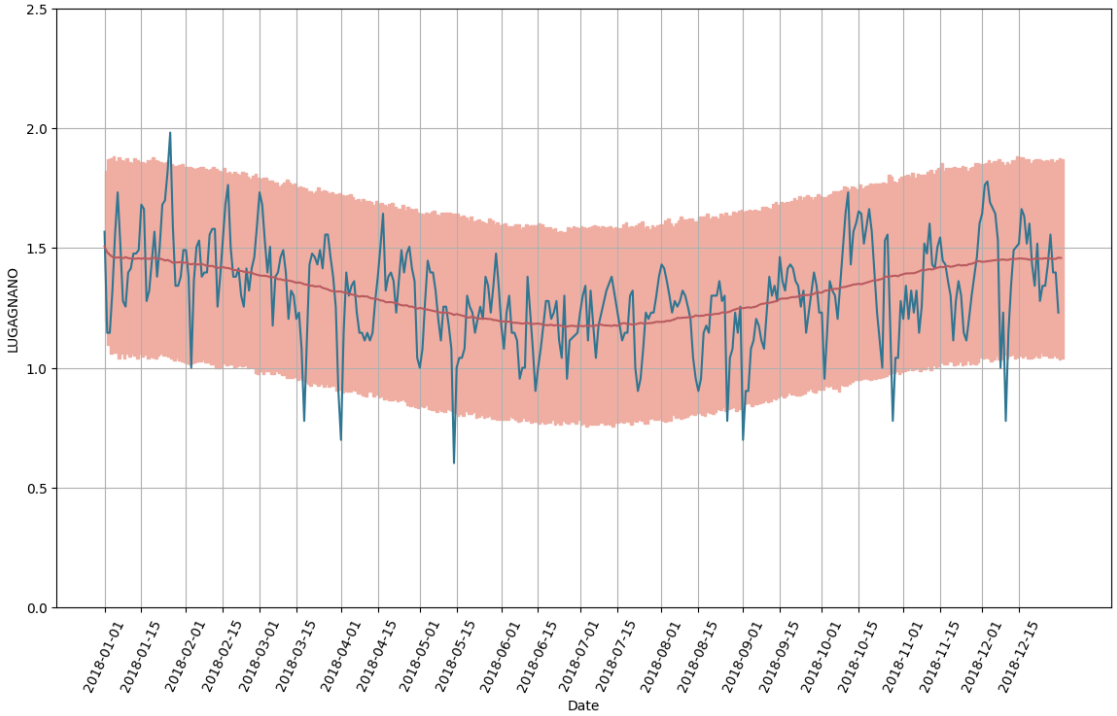
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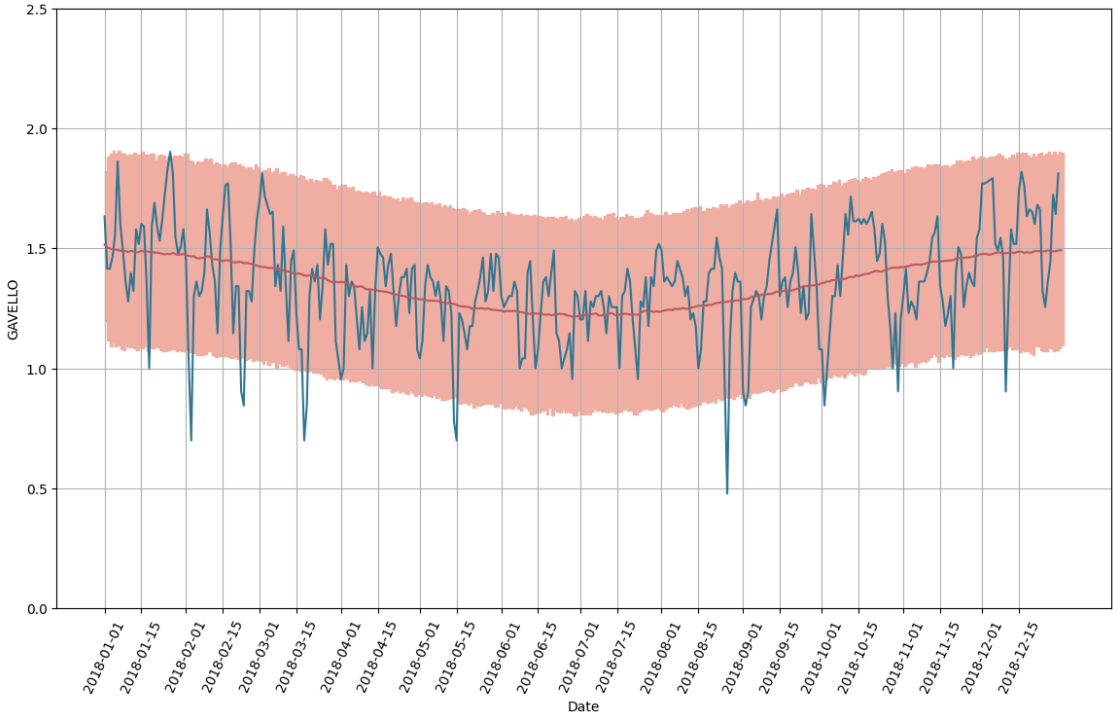
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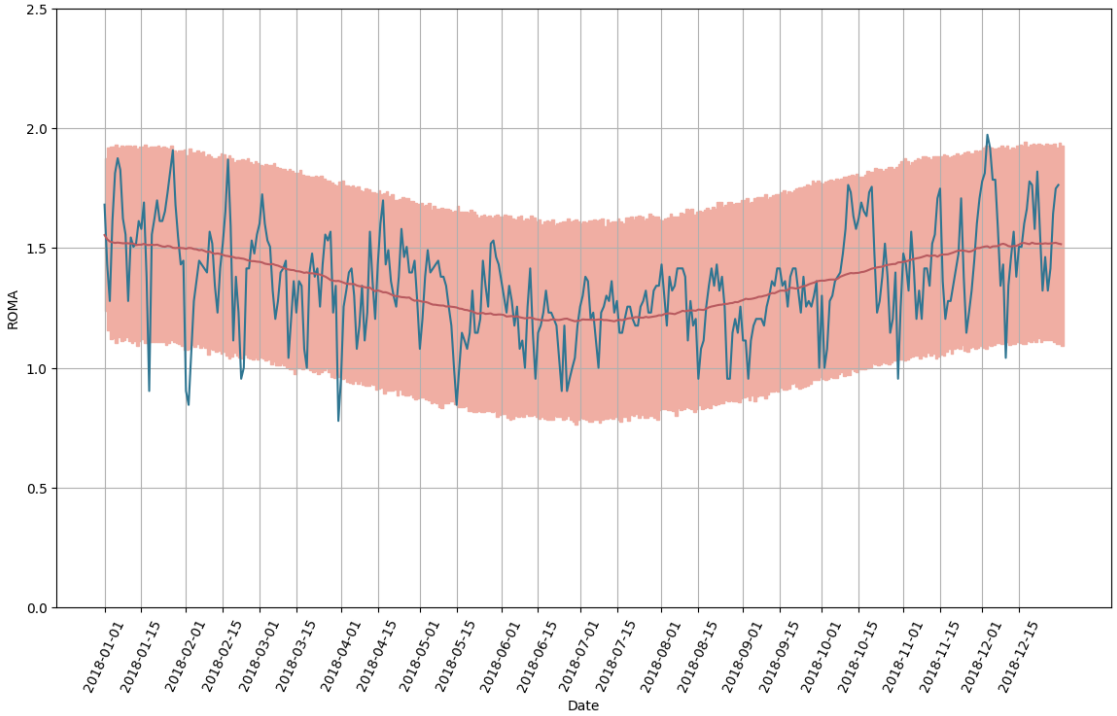
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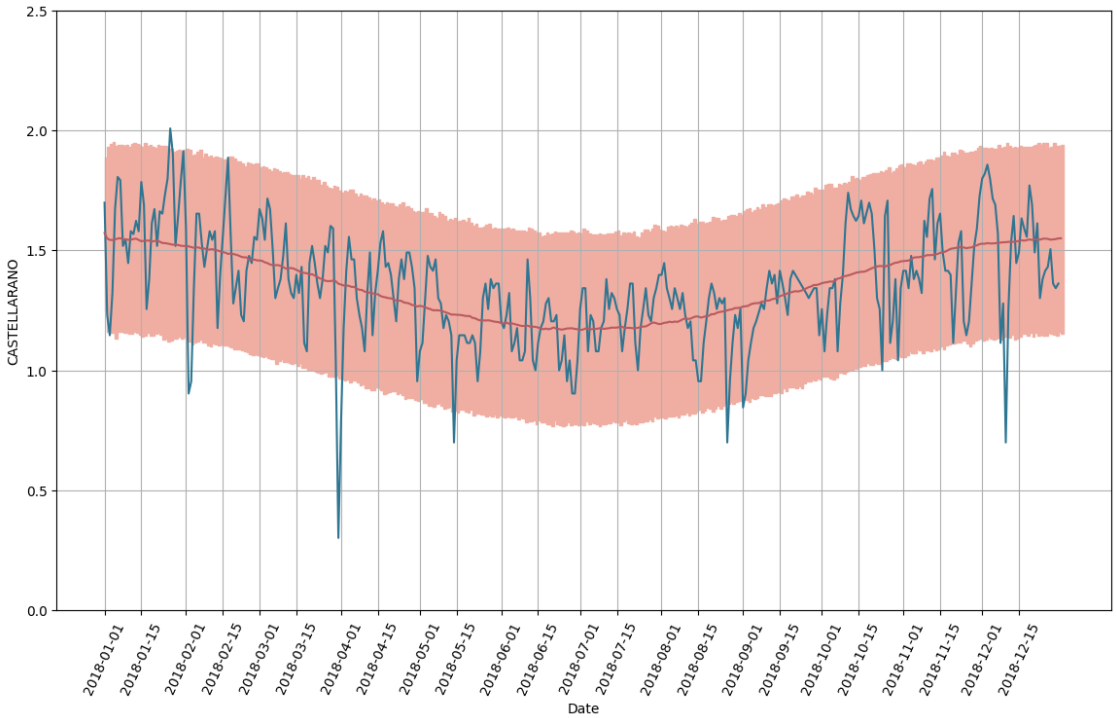
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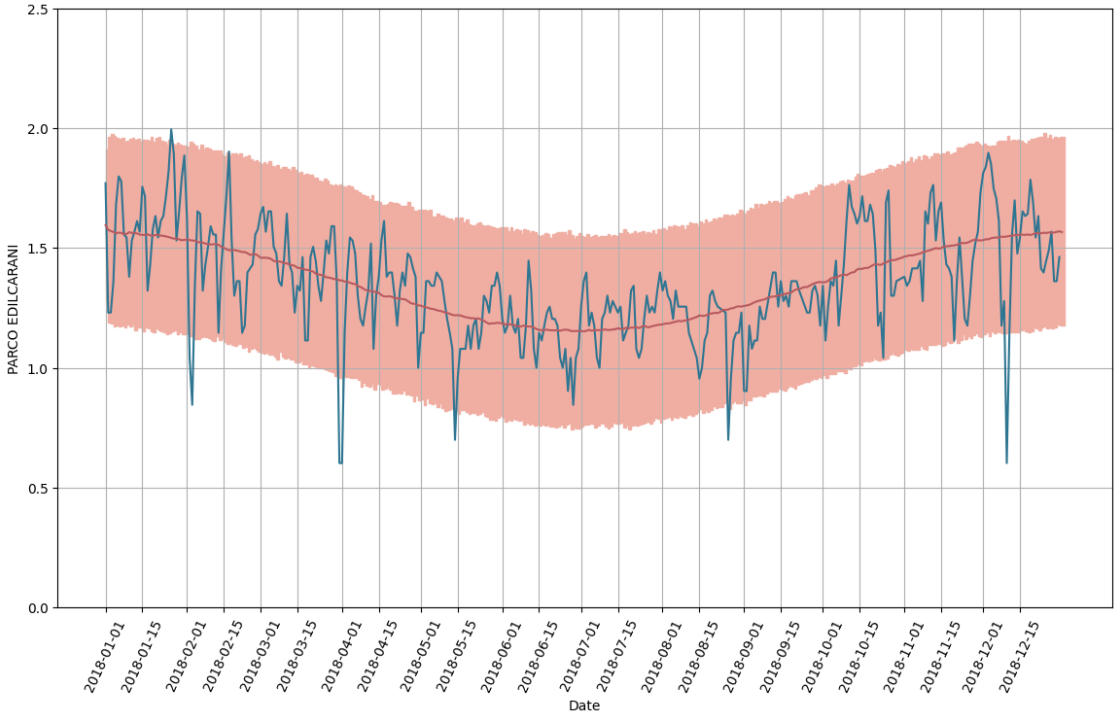
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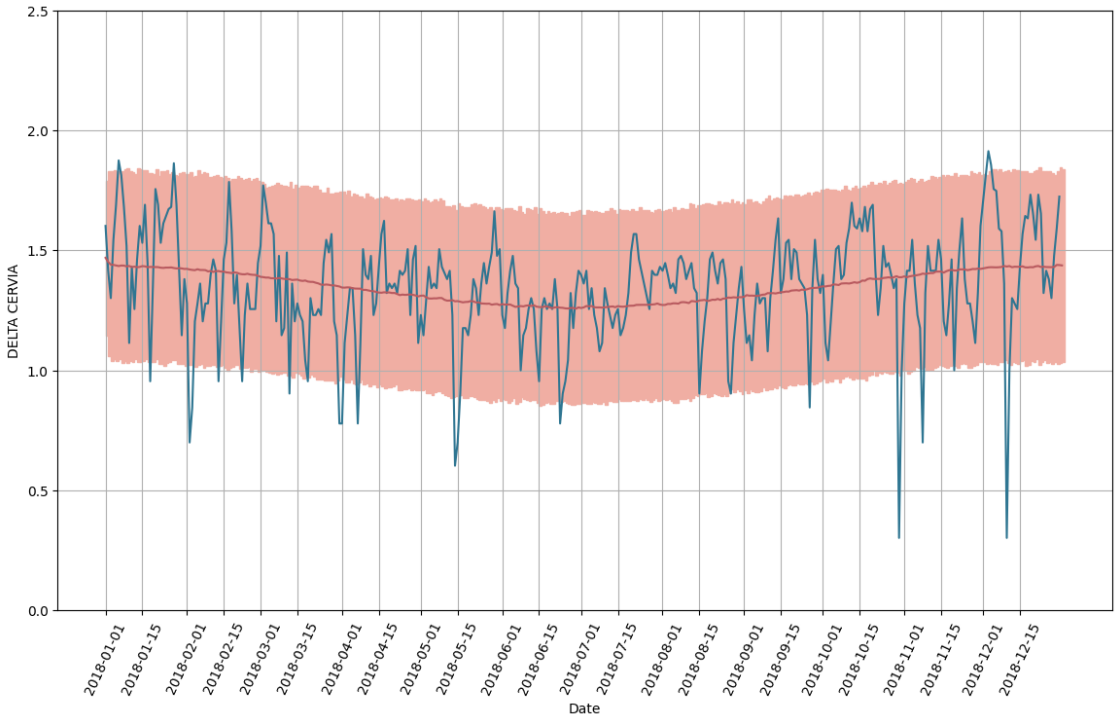
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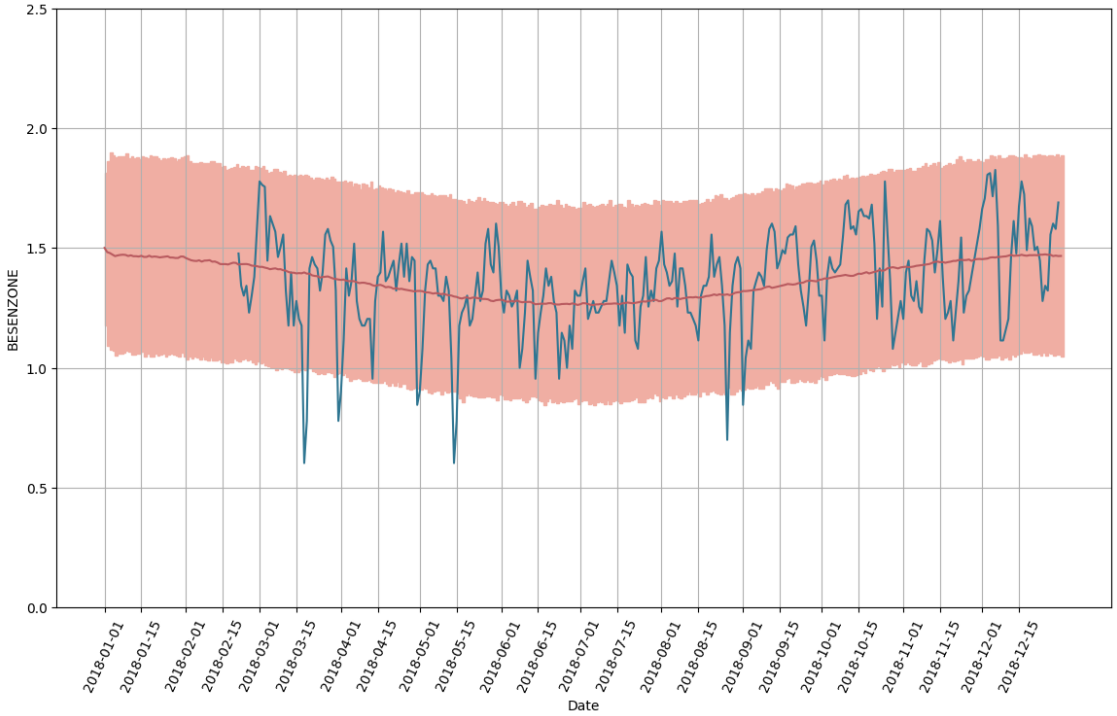
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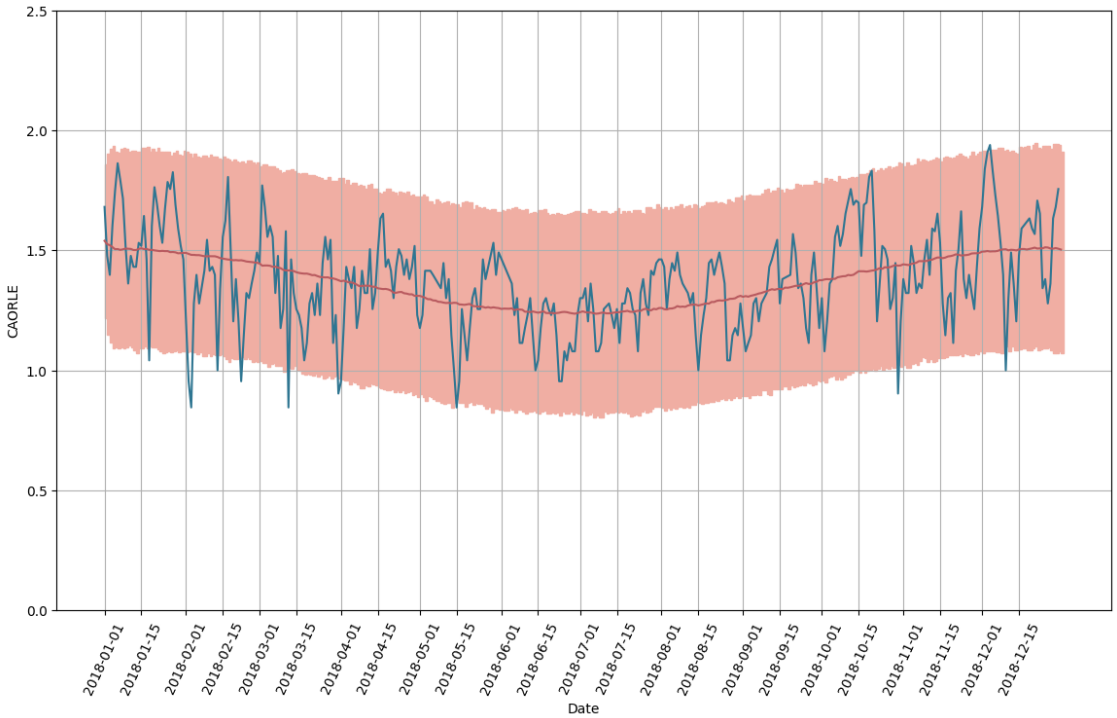
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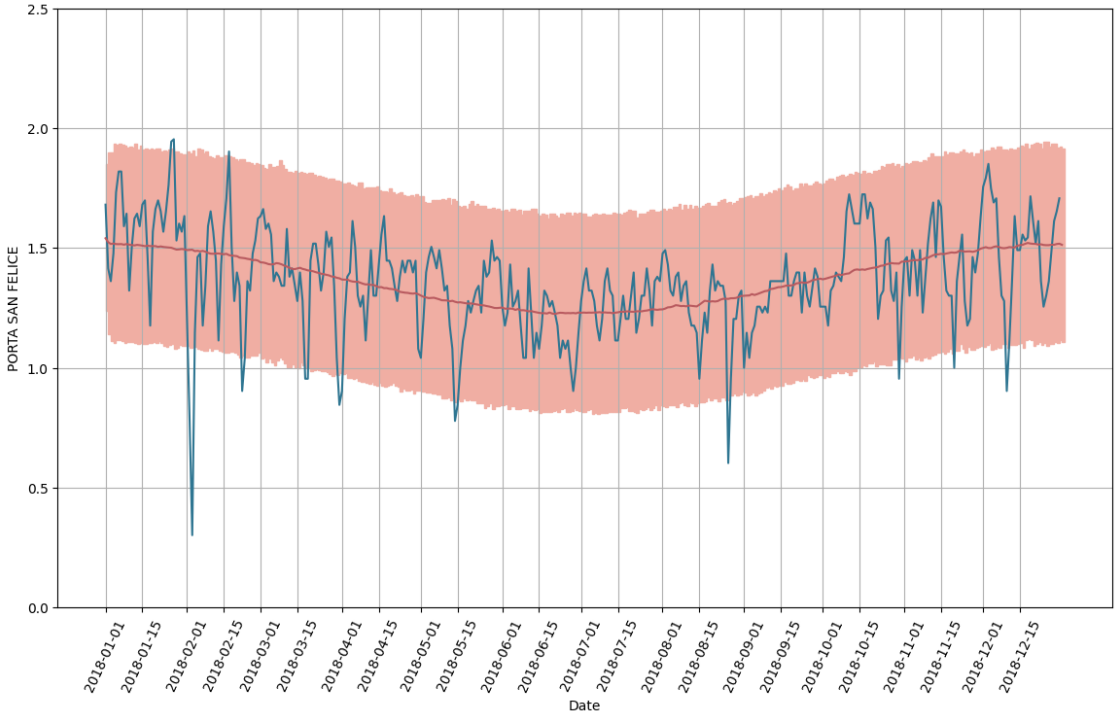
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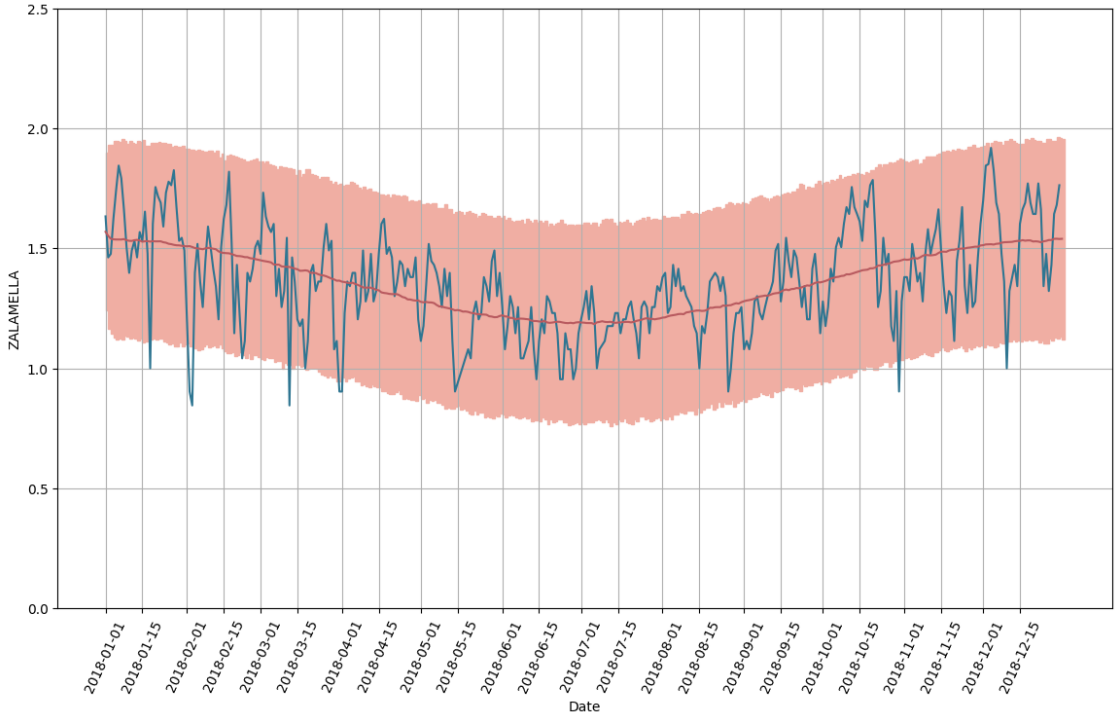
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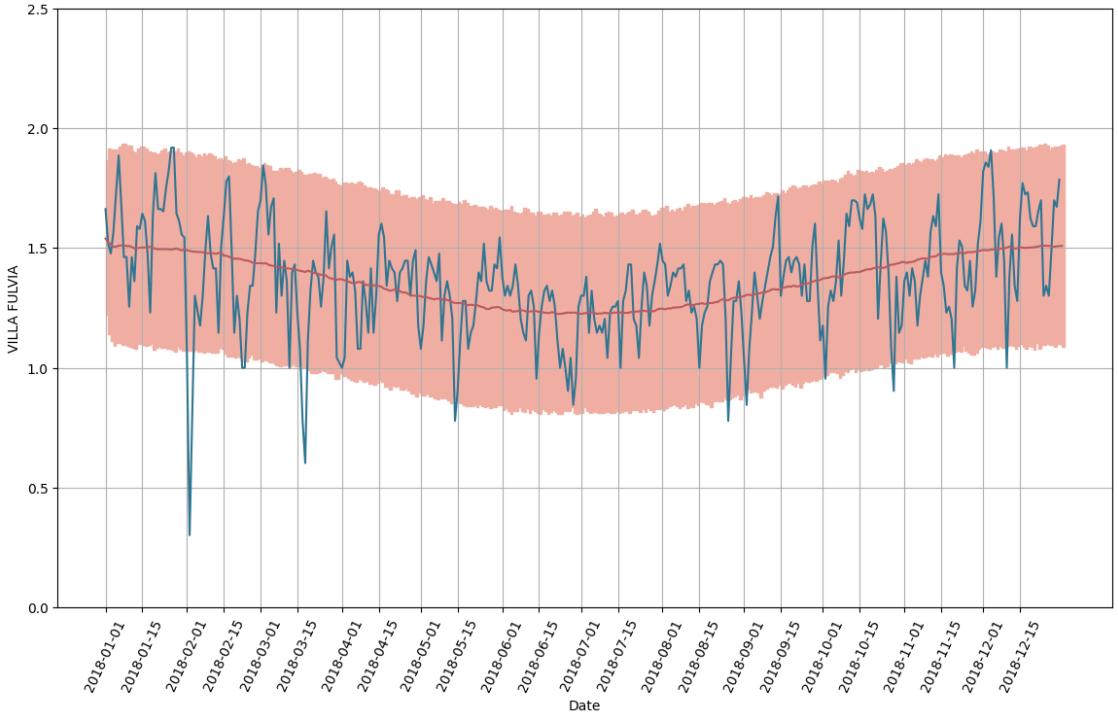
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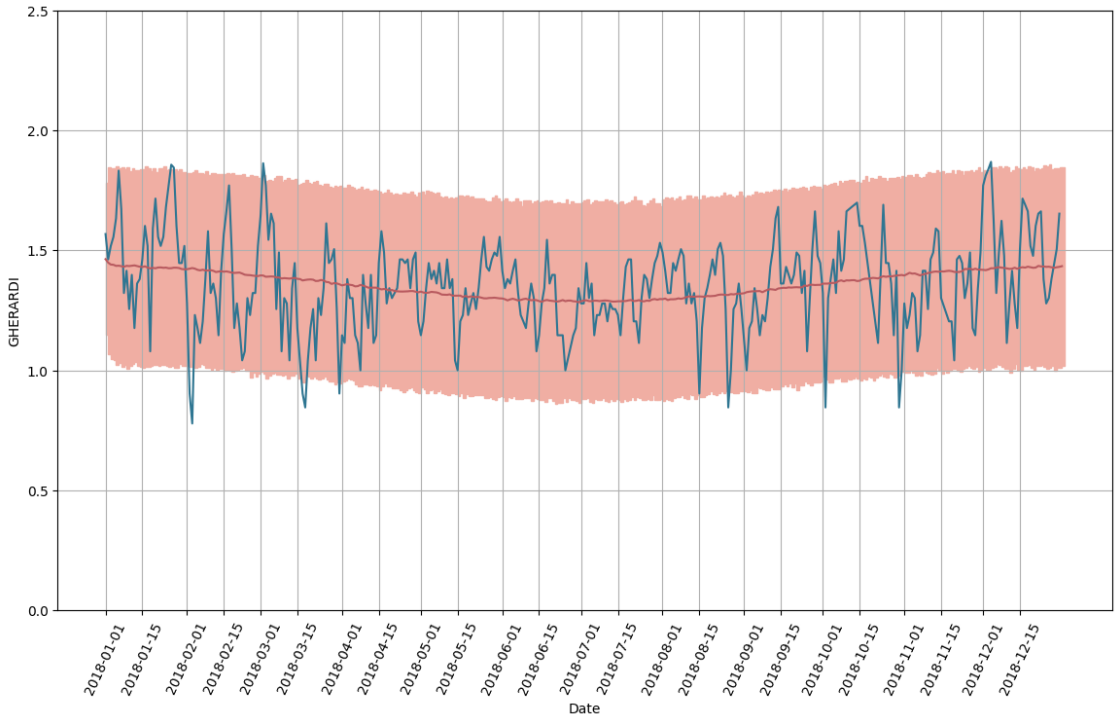
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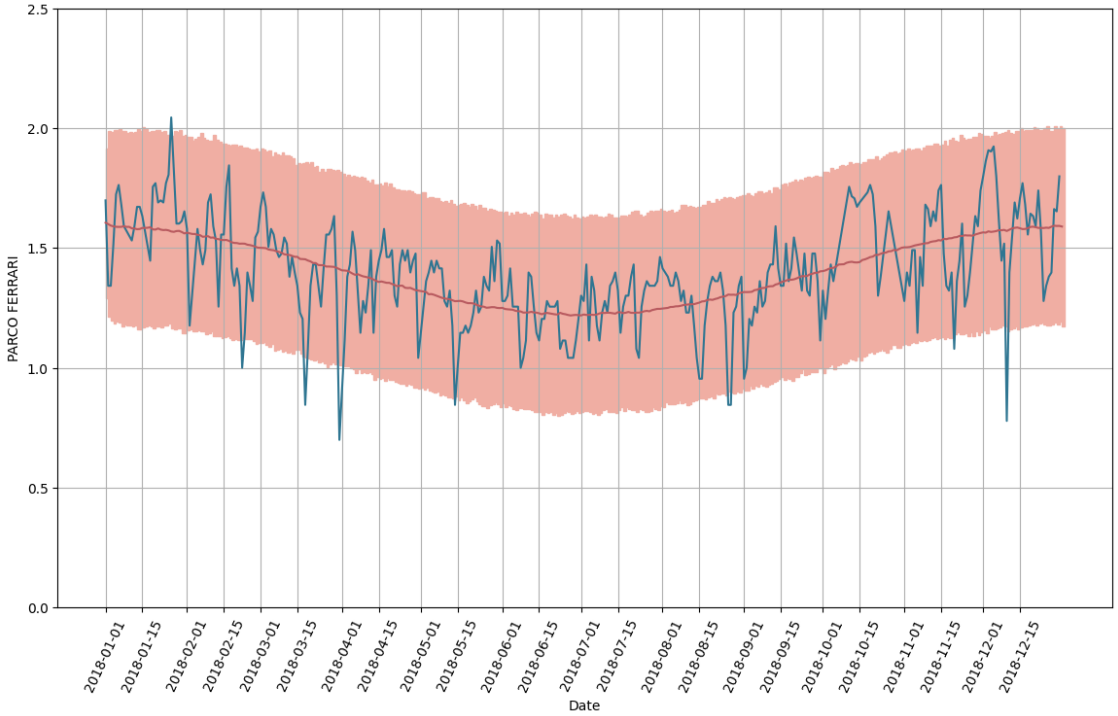
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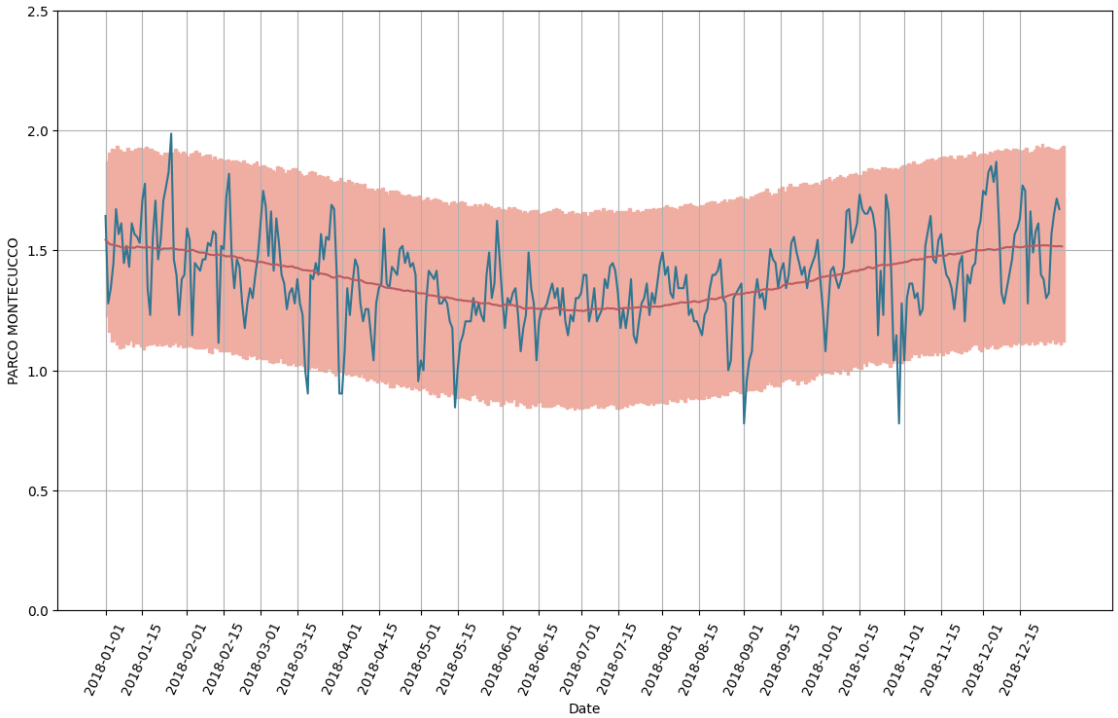
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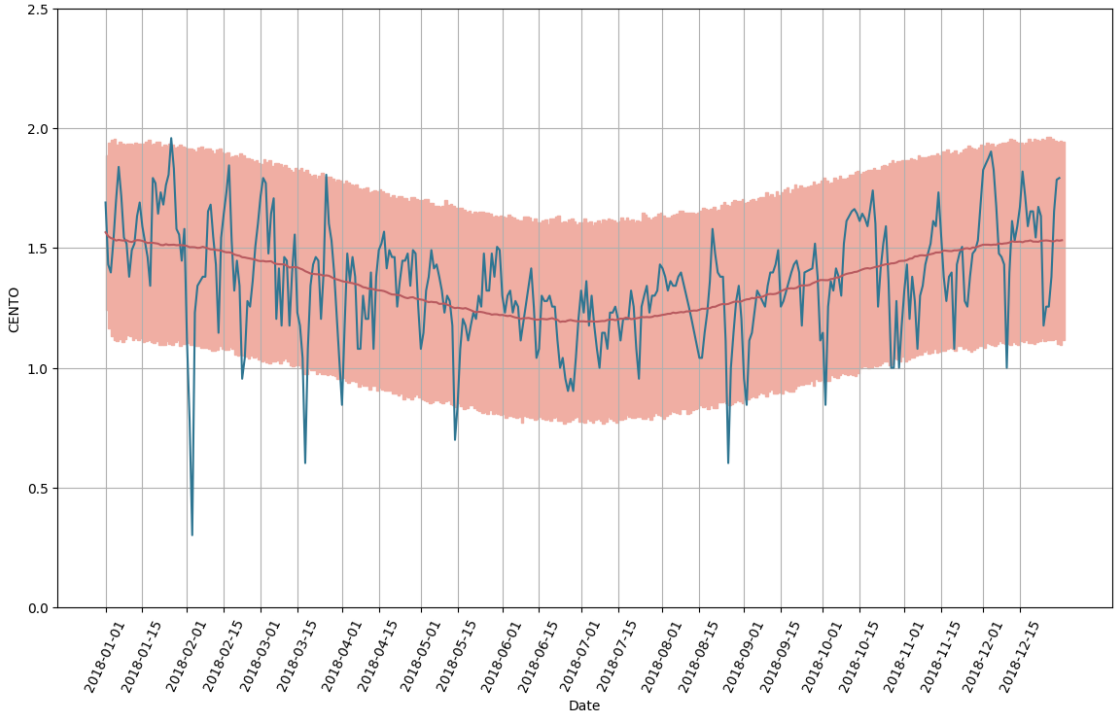
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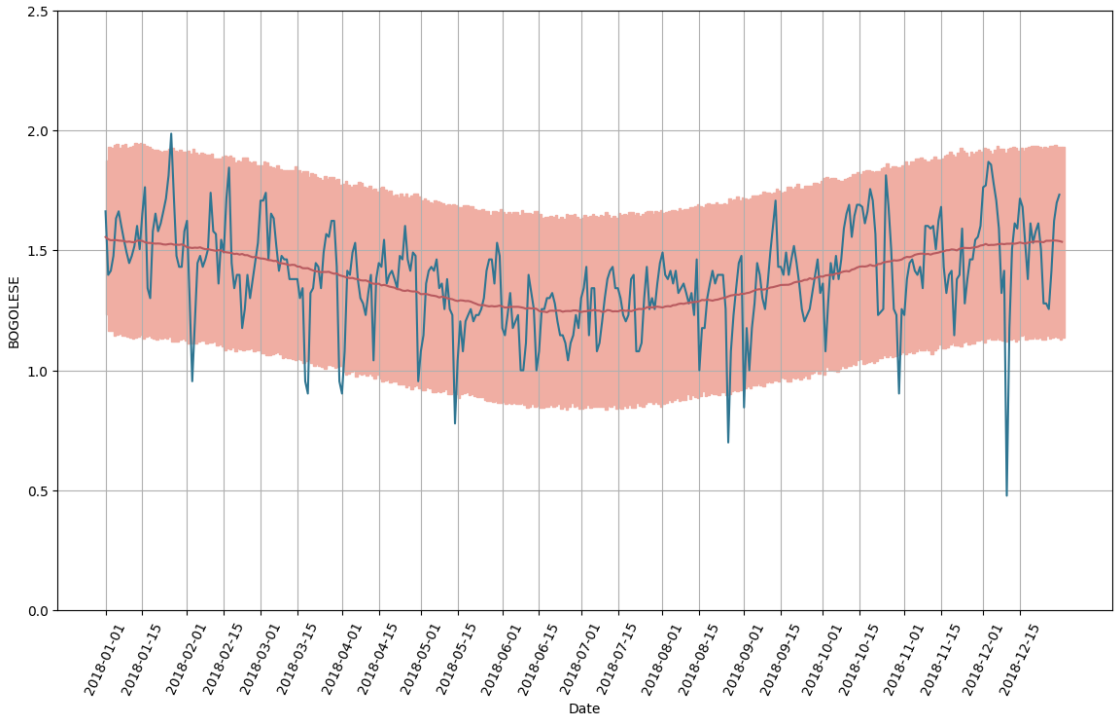
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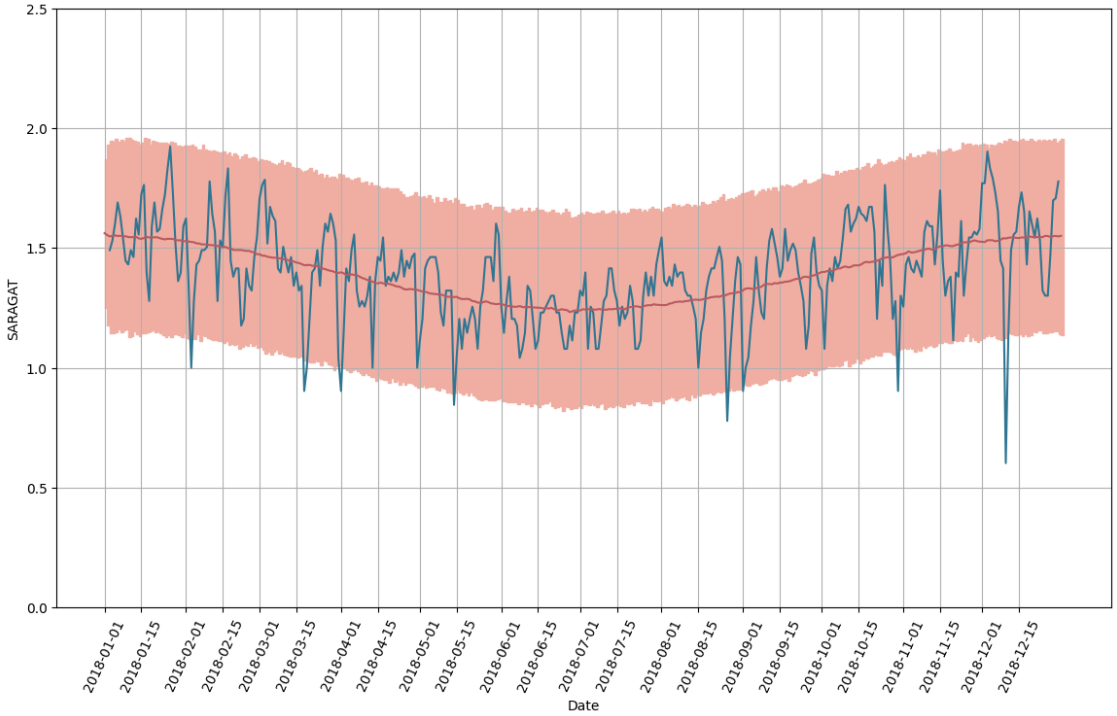
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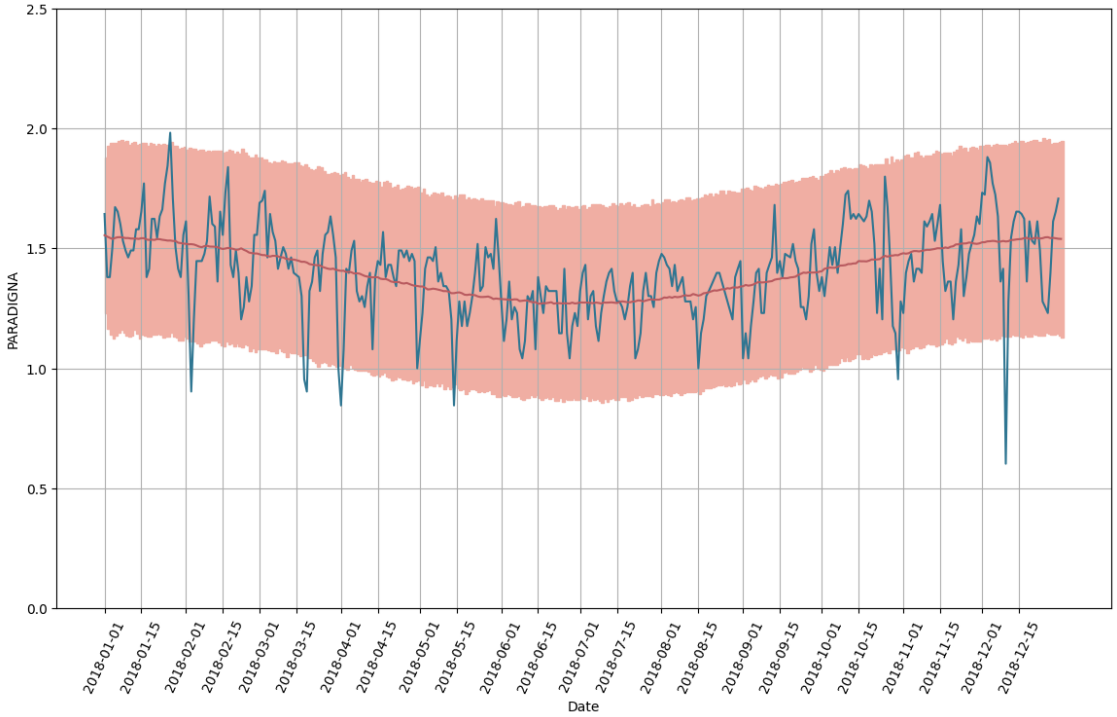
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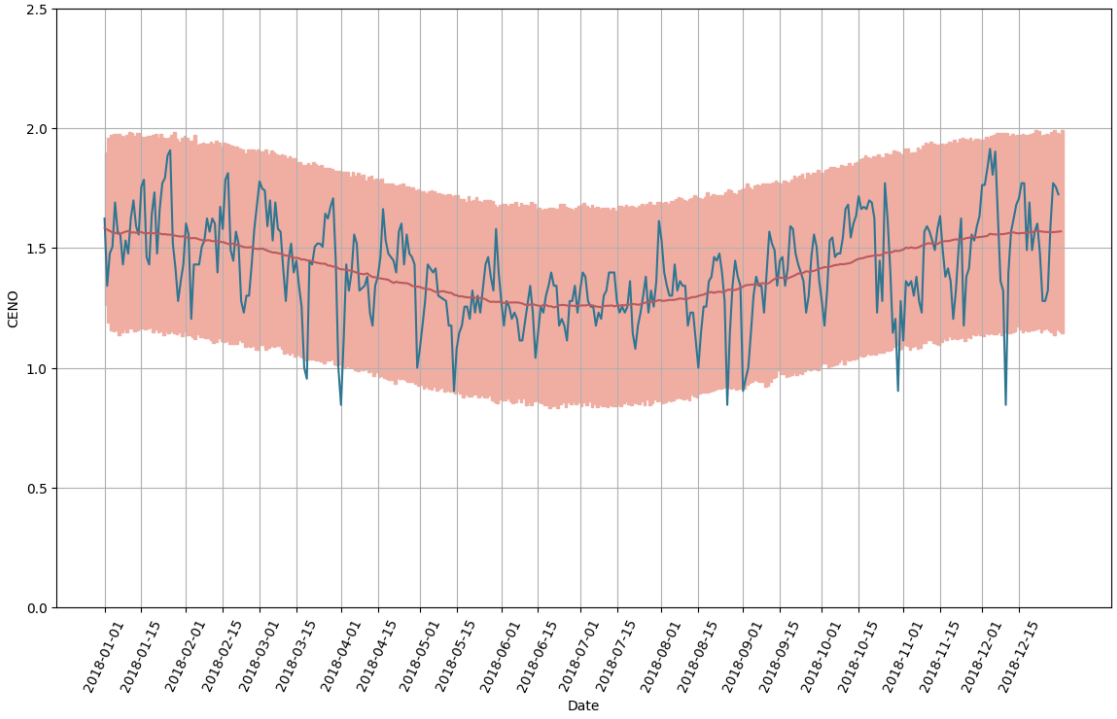
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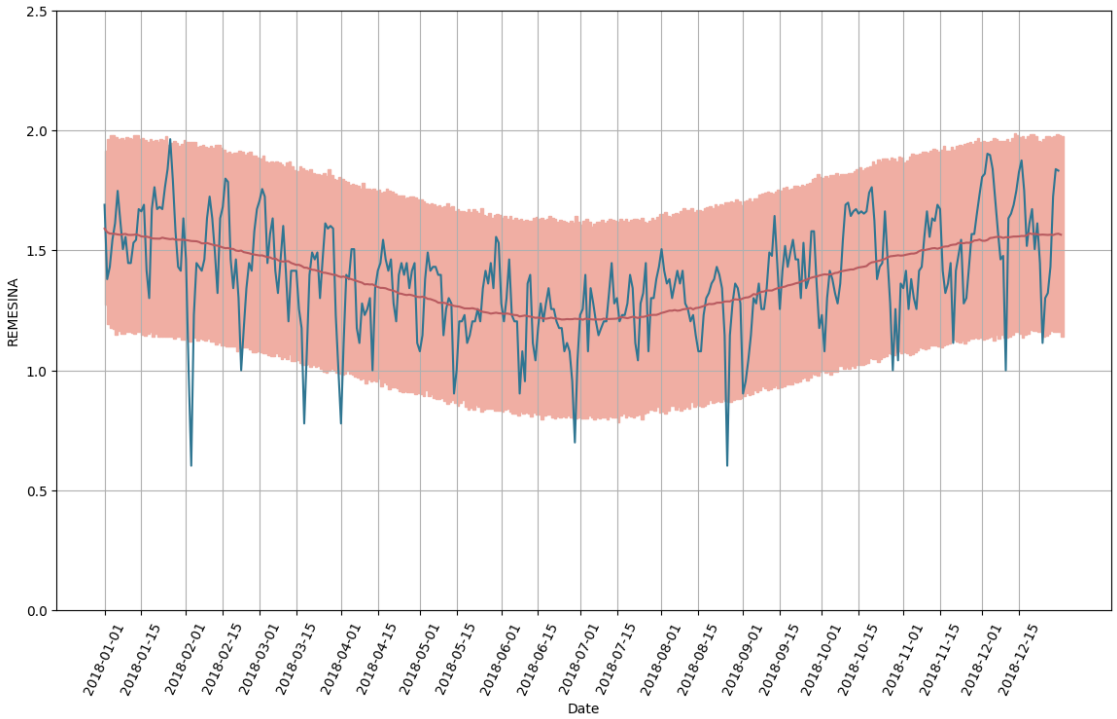
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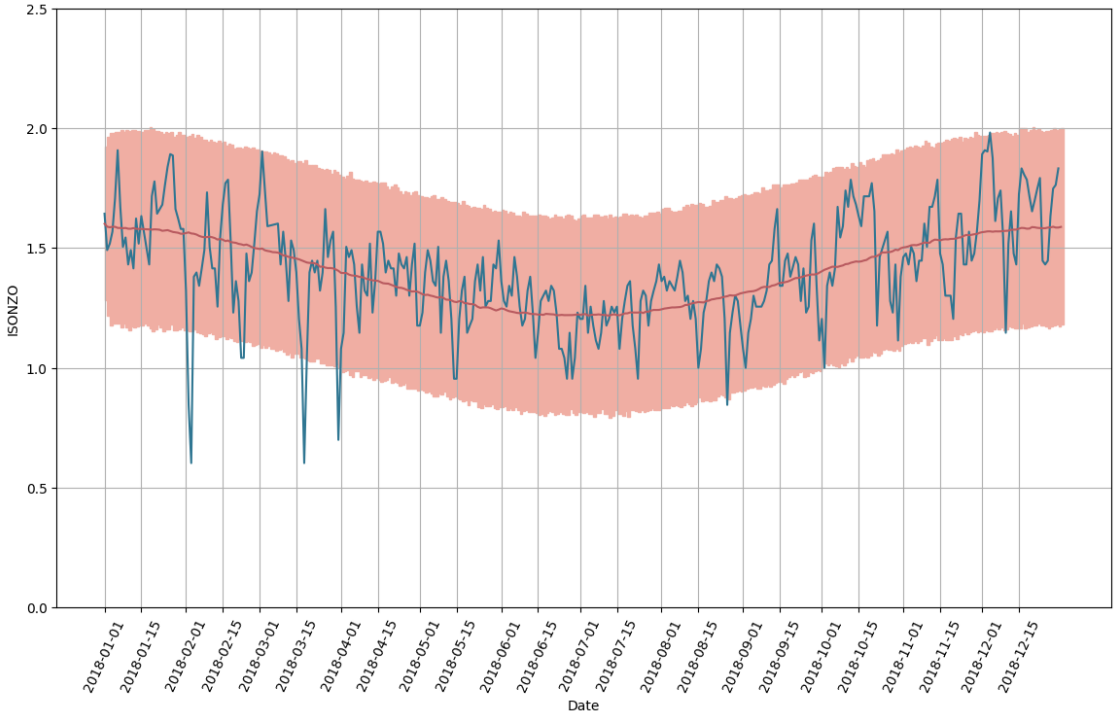
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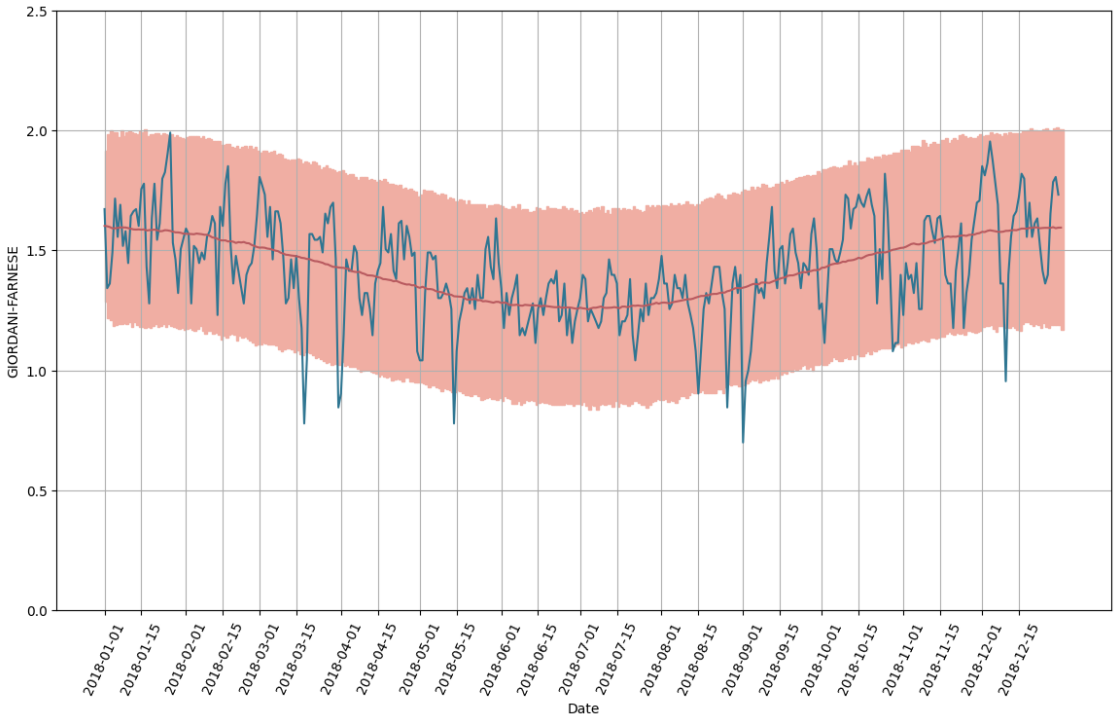
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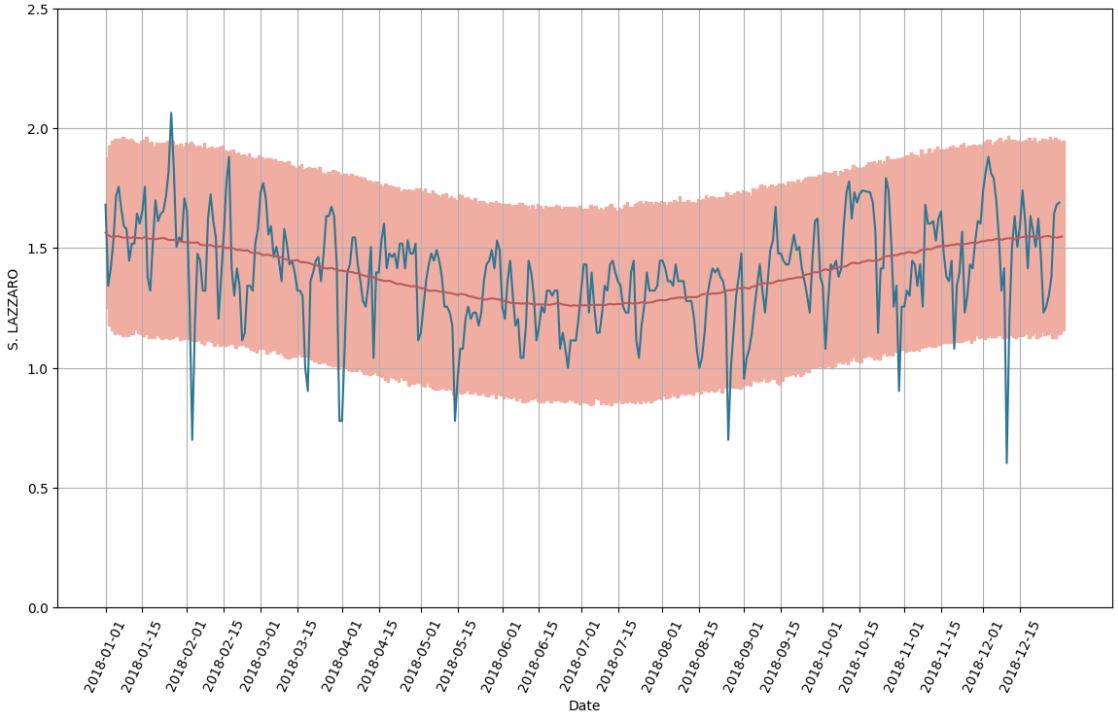
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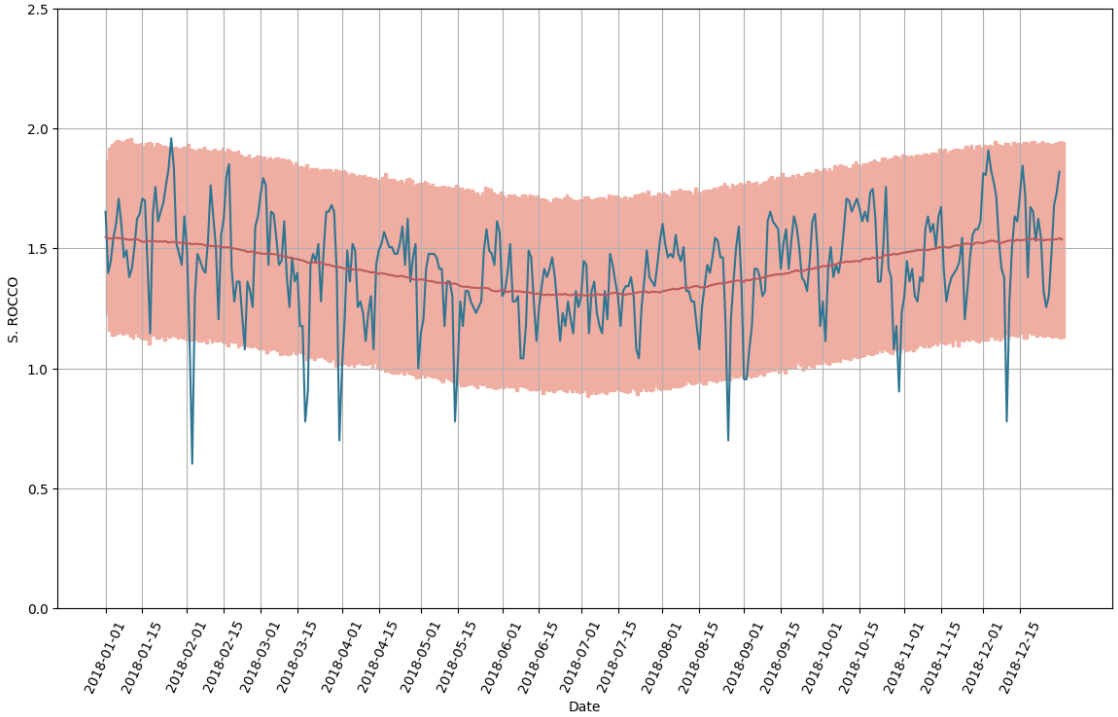
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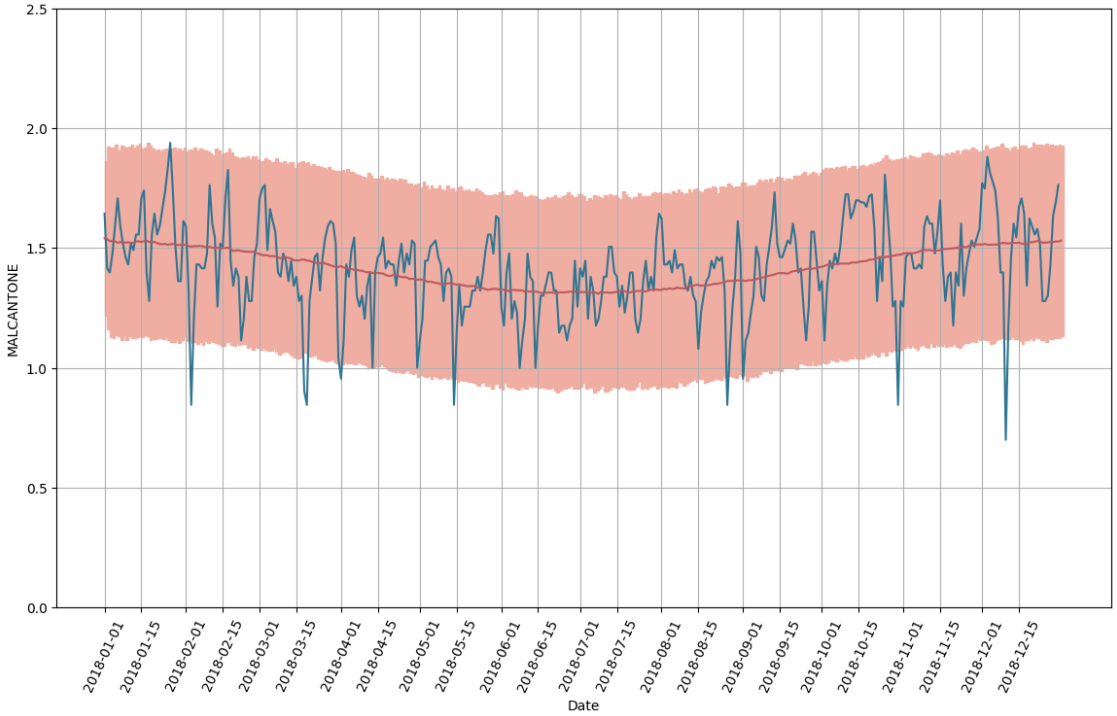
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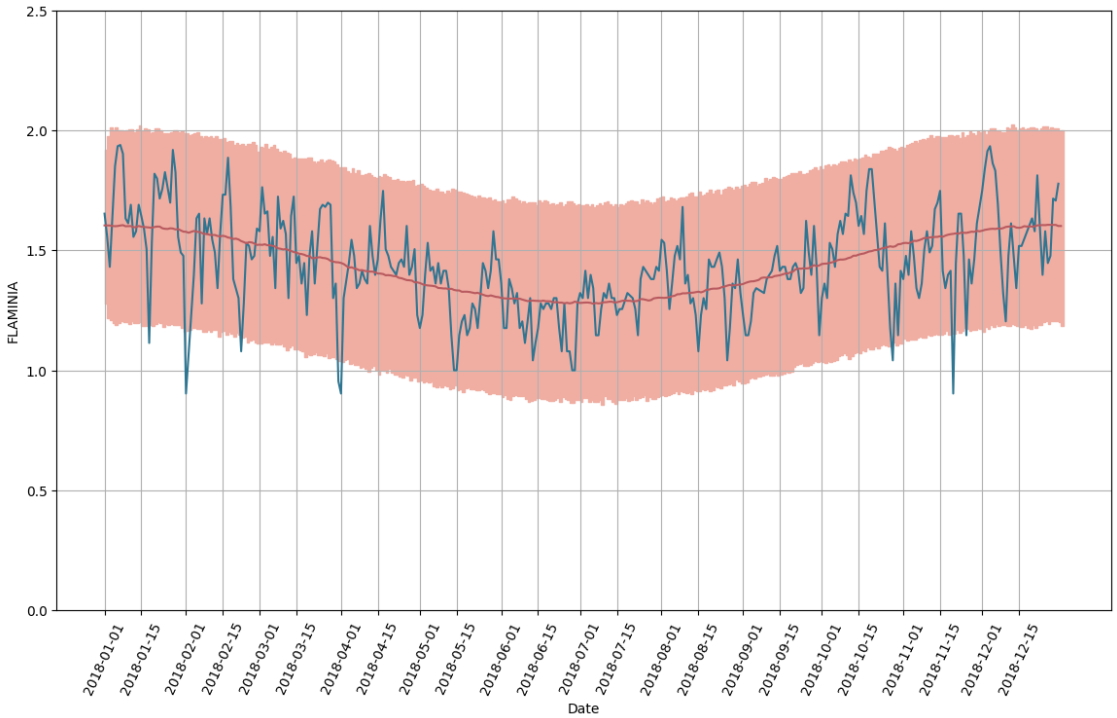
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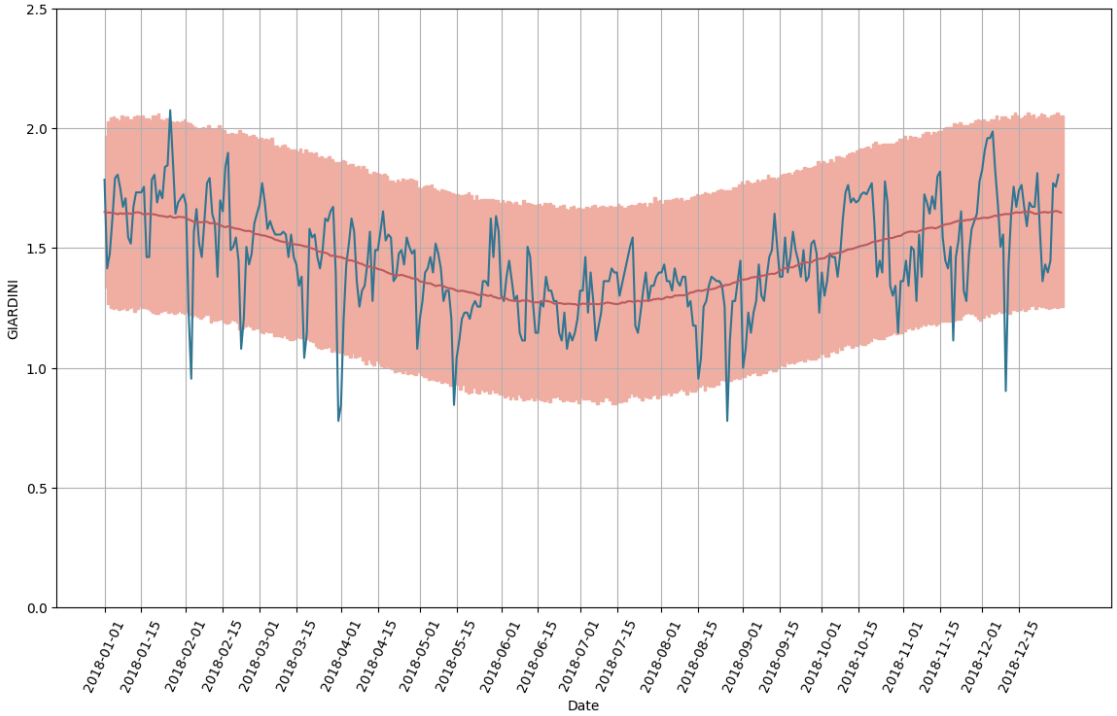
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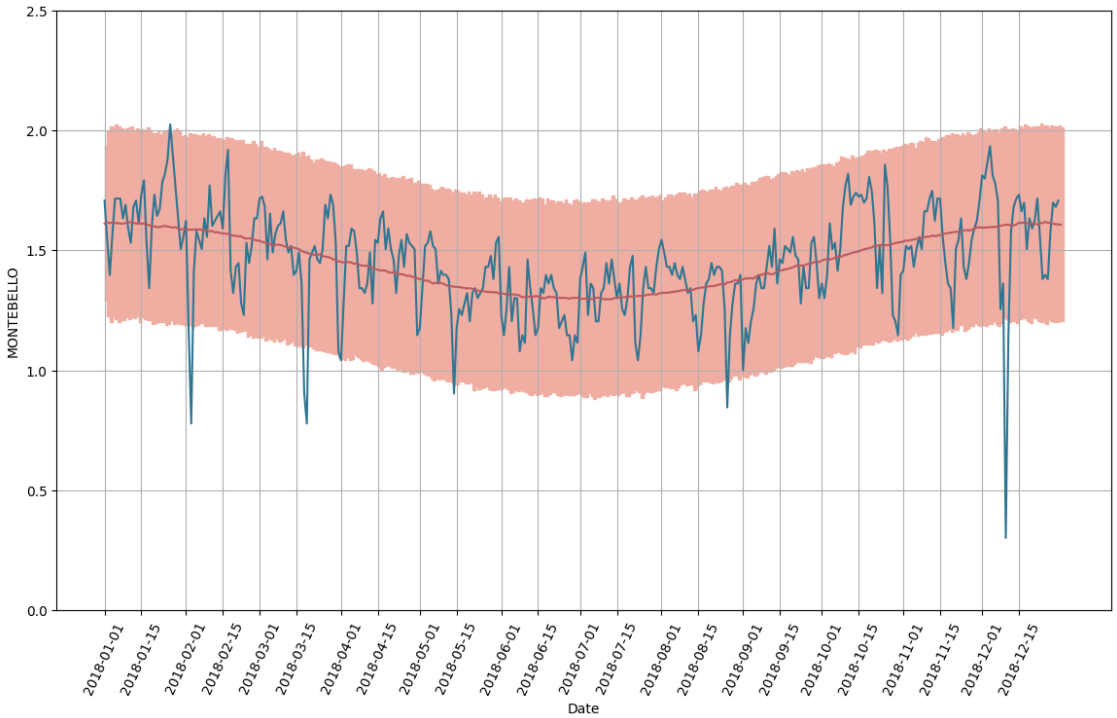
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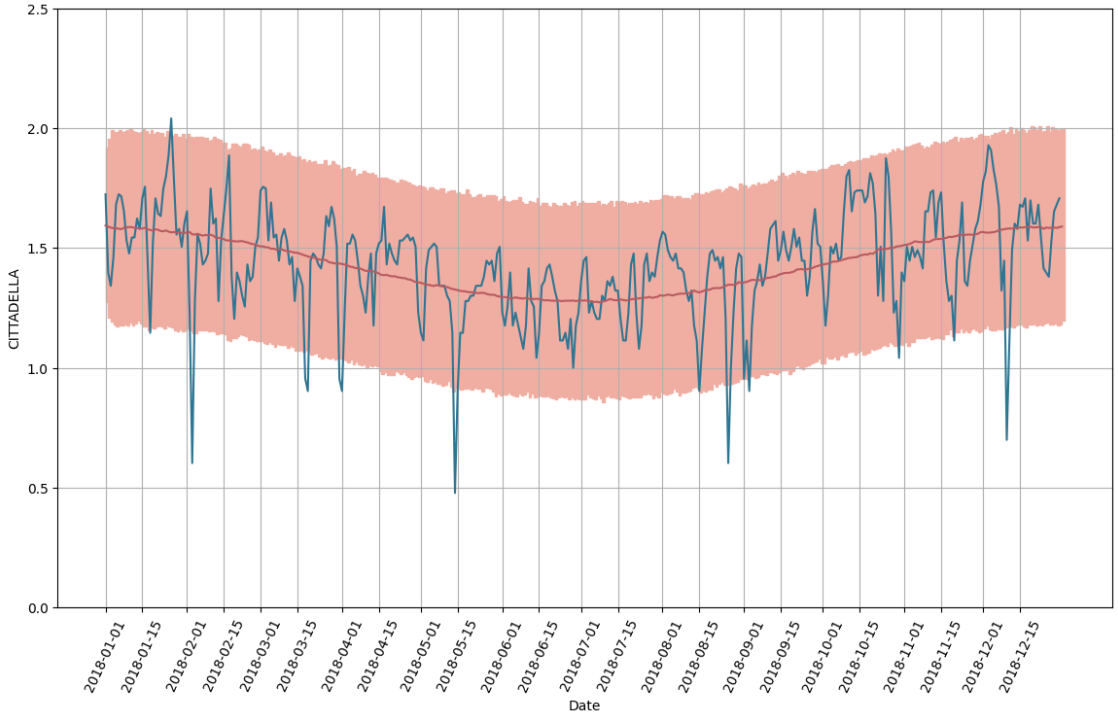
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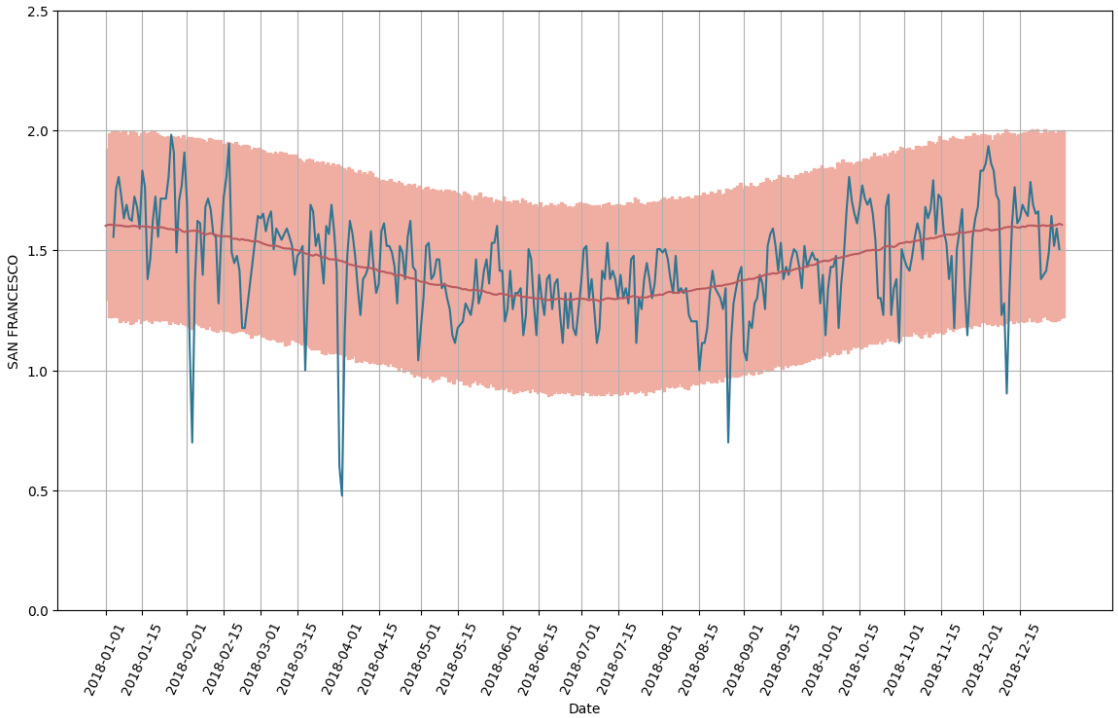
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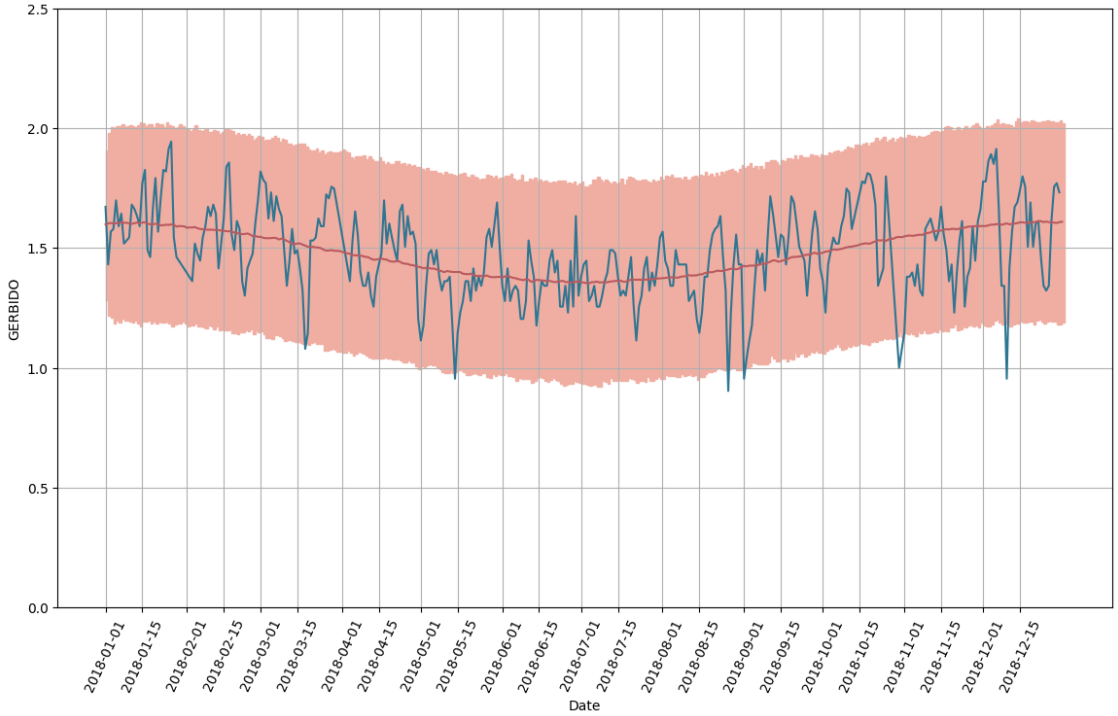
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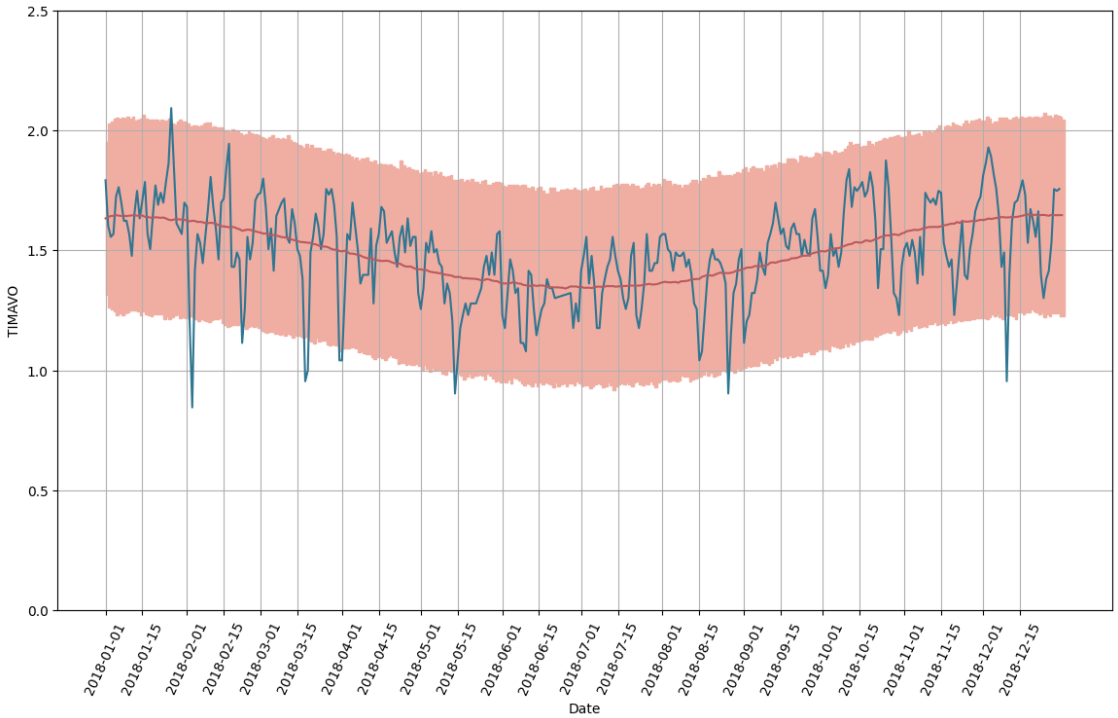
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