
anticipy 0.2.0

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Contents:

OVERVIEW

Anticipy is a tool to generate forecasts for time series. It takes a pandas Series or DataFrame as input, and returns a DataFrame with the forecasted values for a given period of time.

Features:

- **Simple interface.** Start forecasting with a single function call on a pandas DataFrame.
- **Model selection.** If you provide different models (e.g. linear, sigmoidal, exponential), the tool will compare them and choose the best fit for your data.
- **Trend and seasonality.** Support for weekly and monthly seasonality, among other types.
- **Calendar events.** Provide lists of special dates, such as holiday seasons or bank holidays, to improve model performance.
- **Data cleaning.** The library has tools to identify and remove outliers, and to detect and handle step changes in the data.

To get started, install the library with pip:

```
pip install anticipy
```

It is straightforward to generate a simple linear model with the tool - just call `forecast.run_forecast(my_dataframe)()`:

```
import pandas as pd, numpy as np
from anticipy import forecast, forecast_models

df = pd.DataFrame({'y': np.full(20,10.0)+np.random.normal(0.0, 0.1, 20),
                  'date':pd.date_range('2018-01-01', periods=20, freq='D')})
df_forecast = forecast.run_forecast(df, extrapolate_years=0.5)
print(df_forecast.tail(3))
```

Output:

```
.      date source  is_actuals  model      y      q5      q20      q80
↪      q95
219 2018-07-19  src      False  linear  9.490259  7.796581  8.339835  10.556202
↪11.689470
220 2018-07-20  src      False  linear  9.487518  7.828049  8.362620  10.466285
↪11.640854
221 2018-07-21  src      False  linear  9.484776  7.776001  8.343068  10.423964
↪11.696145
```

For more advanced usage, check the [Tutorial](#).

INSTALLATION

To install the project with pip including all the required dependencies do:

```
pip install anticipy
```

To install the optional dependencies, do the following within your virtual environment:

```
pip install -e .[extras]
```


Contents:

- *Getting Started*
- *Input Format*
- *Detailed Output*
- *Forecast models*
- *Models with dummy variables*
- *Outlier Detection*

3.1 Getting Started

To get started, install the library with pip

```
pip install anticipy
```

It is straightforward to generate a forecast with the tool - just call `forecast.run_forecast(my_dataframe)()`:

```
import pandas as pd, numpy as np
from anticipy import forecast, forecast_models, forecast_plot

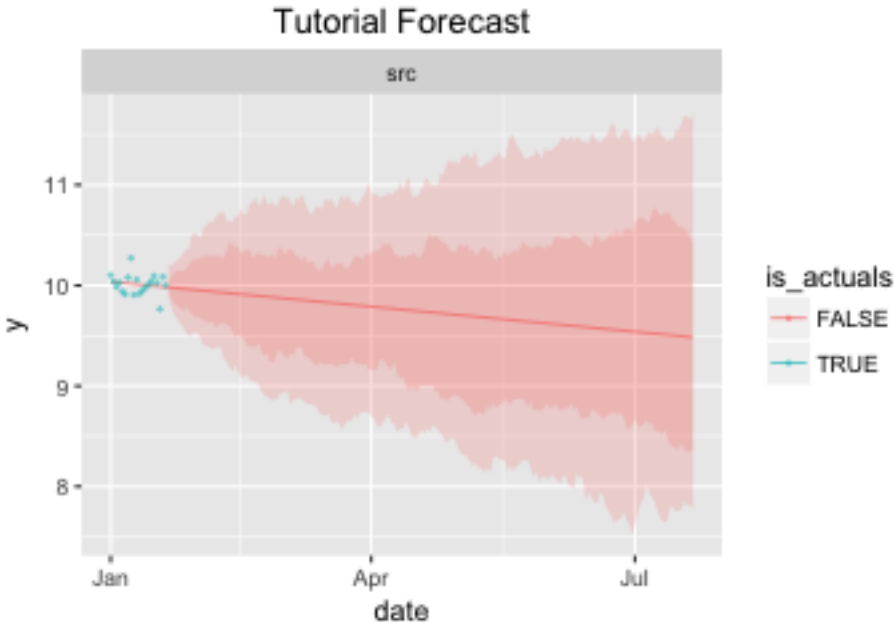
df = pd.DataFrame({'y': np.full(20,10.0)+np.random.normal(0.0, 0.1, 20),
                  'date':pd.date_range('2018-01-01', periods=20, freq='D')})
df_forecast = forecast.run_forecast(df, extrapolate_years=0.5)
print(df_forecast.tail(3))
```

Output:

```
.      date source  is_actuals  model      y      q5      q20      q80
↪      q95
219 2018-07-19  src      False  linear  9.490259  7.796581  8.339835  10.556202
↪11.689470
220 2018-07-20  src      False  linear  9.487518  7.828049  8.362620  10.466285
↪11.640854
221 2018-07-21  src      False  linear  9.484776  7.776001  8.343068  10.423964
↪11.696145
```

The tool automatically selects the best model from a list of defaults - in this case, a simple linear model. Advanced users can instead provide their preferred model or lists of candidate models, as explained in *Forecast models*.

You can plot the forecast output using the functions in `forecast_plot`. `anticipy.forecast_plot.plot_forecast()` saves the plot as a file or exports it to a jupyter notebook. The plot looks as follows:



The code to generate the plot is:

```
path_tutorial_plot = 'plot-tutorial'
# Save plot as a file
forecast_plot.plot_forecast(df_forecast, output='html',
path=path_tutorial_plot, width=350, height=240, title='Tutorial Forecast')
# Show plot in a jupyter notebook
forecast_plot.plot_forecast(df_forecast, output='jupyter', width=350,
height=240, title='Tutorial Forecast')
```

3.2 Input Format

The input time series needs to be formatted as a pandas series or dataframe. If a dataframe is passed, the following columns are used:

- **y:** float, values of the time series.
- **date:** (optional) timestamp, date and time of each sample. If this column is not present, and the dataframe index is a `DatetimeIndex`, the index will be used instead. This is an optional column, only required when using models that are aware of the date, such as weekly seasonality models.
- **x:** (optional) float or int, numeric index of each sample. If this column is not present, it will be inferred from the date column or, if that is not possible, the dataframe index will be used instead.
- **source:** (optional) string, the name of the data source for this time series. You can include multiple time series in your input dataframe, using different source values to identify them.

If a series is passed, 'y' will be the series values and, if the index is a `DateTimeIndex`, it will be used as the 'date' column. If the index is numeric, it will be used as the 'x' column instead.

An input dataframe should meet the following constraints:

- Minimum required samples depends on number of parameters in the chosen models. `run_forecast()` will fail to fit if `n_samples < n_parameters+2`
- `y` column may include null values.
- Multiple values per sample may be included, e.g. when the same metric is observed by multiple sources. In that case, it is possible to assign weights to each individual sample so that one source will be given higher priority. To do that, include a 'weight' column of floats in the input dataframe.
- A date column or date index is only required if the model is date-aware.
- Non-default column names may be used. In that case, you need to pass the new column names to `run_forecast()` using the `col_name_` parameters.

Here is an example of using `col_name_` parameters to run a forecast with non-default column names:

```
df2 = pd.DataFrame({'my_y': np.full(20,10.0)+np.random.normal(0.0, 0.1, 20),
                   'my_date':pd.date_range('2018-01-01', periods=20, freq='D')})
df_forecast2 = forecast.run_forecast(df2, extrapolate_years=0.5,
                                     col_name_y='my_y',
                                     col_name_date='my_date')
```

3.3 Detailed Output

The library uses `scipy.optimize` to fit model functions to the input data. You can examine the model parameters, quality metrics and other useful information with the argument `simplify_output=False`:

```
dict_result = forecast.run_forecast(df, extrapolate_years=0.5,
                                   simplify_output=False, include_all_fits=True)
# Table with actuals and forecast for best-fitting model, including prediction_
↳ intervals
print dict_result['forecast'].groupby('model').tail(1)
# Table including time series actuals and forecast
print dict_result['data'].groupby('model').tail(1)
# Metadata table: model parameters and fitting output
print dict_result['metadata']
# Table with output data from scipy.optimize, for debugging purposes
print dict_result['optimize_info']
```

Output - forecast table, same as output from `run_forecast(simplify_output=True)`:

.	date	source	is_actuals	model	y	q5	q20	↳
↳	q80	q95						
19	2018-01-20	src	True	y	9.928176	NaN	NaN	↳
↳	NaN	NaN						
221	2018-07-21	src	False	(linear+ramp)	10.838865	9.597208	10.121438	11.↳
↳	717812	12.551523						

Output - data table. Has actuals and forecasts, including forecasts from non-optimal models if `include_all_fits=True`

.	date	model	y	source	↳
↳	source_long	is_actuals	is_weight	is_filtered	is_best_fit
19	2018-01-20	weight	1.000000	src	src:1-1:D:2018-01-
↳	01::2018-01-20	True	True	False	False
39	2018-01-20	y	9.928176	src	src:1-1:D:2018-01-
↳	01::2018-01-20	True	False	False	False

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241	2018-07-21		linear	9.230972	src	src:1-1:D:2018-01-01::2018-01-20	False	False	False	False
443	2018-07-21		(linear+season_wday)	9.283372	src	src:1-1:D:2018-01-01::2018-01-20	False	False	False	False
645	2018-07-21		(linear+ramp)	10.838865	src	src:1-1:D:2018-01-01::2018-01-20	False	False	False	True
847	2018-07-21		((linear+ramp)+season_wday)	10.989835	src	src:1-1:D:2018-01-01::2018-01-20	False	False	False	False

Output - metadata table. Includes model parameters and model quality metrics such as cost and AICC:

.	source		model	weights	actuals_x_range	freq	is_fit	
↪	cost	aic_c				params_str	status	
↪		source_long					params	is_
↪	best_fit							
0	src		linear	1-1	2018-01-01::2018-01-20	D	True	0.
↪	063076	-111.182993						
↪	1:D:2018-01-01::2018-01-20							
↪	False							
1	src		(linear+season_wday)	1-1	2018-01-01::2018-01-20	D	True	0.
↪	039519	-95.533948						
↪	1:D:2018-01-01::2018-01-20							
↪	False							
2	src		(linear+ramp)	1-1	2018-01-01::2018-01-20	D	True	0.
↪	045997	-111.498115						
↪	1:D:2018-01-01::2018-01-20							
↪	True							
3	src		((linear+ramp)+season_wday)	1-1	2018-01-01::2018-01-20	D	True	0.
↪	020303	-93.853970						
↪	1:D:2018-01-01::2018-01-20							
↪	False							

Output - optimize information table. Includes detailed data generated by scipy.optimize, useful for debugging:

.	source		model	success				
↪	params_str	cost	optimality	iterations	status	jac_evals		
↪		message			source_long			
↪		params						
0	src		linear	True				
↪	03	1.0e+01]						
↪	termination condition is satisfied.	0.063076	1.213028e-09	4	1	4	`gtol`	
↪	0038931365581278176, 10.013491979601325]							
1	src		(linear+season_wday)	True				
↪	8.4e-02 ...	0.039519	8.348877e-14	4	1	4	`gtol`	
↪	termination condition is satisfied.	0.032764198059819344, 9.975993454168774, 0....						
2	src		(linear+ramp)	True				
↪	1	6. 0.]						
↪	termination condition is satisfied.	0.045997	1.765921e-03	34	2	22	`ftol`	
↪	030005422538483477, 10.103677325164737, 6....							
3	src		((linear+ramp)+season_wday)	True				
↪	1.1e-01 ...	0.020303	2.777755e-02	45	2	28	`ftol`	
↪	termination condition is satisfied.	0.0318590092714045, 10.062880686158646, 6.00...						

3.4 Forecast models

By default, `run_forecast()` automatically generates a list of candidate models. However, you can specify a list of models in the argument `l_model_trend`, so that the tool fits each model and chooses the best. Only the best fitting model will be included in the output, unless you use the argument `include_all_fits=True`. The following example runs a forecast with two models: linear and constant:

```
dict_result = forecast.run_forecast(df, extrapolate_years=1, simplify_output=False,
                                   l_model_trend = [forecast_models.model_linear,
                                                    forecast_models.model_constant],
                                   include_all_fits=True)
# Table including time series actuals and forecast
print dict_result['data'].tail(6)
# Metadata table: model parameters and fitting output
print dict_result['metadata']
```

Output:

.	date	model	y	source	source_long	is_actuals
↪ is_weight	is_filtered	is_best_fit				
739	2018-12-31	constant	2.0	src	src:1:D:2018-01-01::2018-01-05	False
↪ False	False	False				
740	2019-01-01	constant	2.0	src	src:1:D:2018-01-01::2018-01-05	False
↪ False	False	False				
741	2019-01-02	constant	2.0	src	src:1:D:2018-01-01::2018-01-05	False
↪ False	False	False				
742	2019-01-03	constant	2.0	src	src:1:D:2018-01-01::2018-01-05	False
↪ False	False	False				
743	2019-01-04	constant	2.0	src	src:1:D:2018-01-01::2018-01-05	False
↪ False	False	False				
744	2019-01-05	constant	2.0	src	src:1:D:2018-01-01::2018-01-05	False
↪ False	False	False				

.	source	model	weights	actuals_x_range	freq	is_fit	cost
↪ aic_c	params_str	status					
↪	params	is_best_fit					
0	src	linear	1	2018-01-01::2018-01-05	D	True	6.162976e-33 -368.
↪ 880931	[1.0e+00 1.1e-16]	FIT		src:1:D:2018-01-01::2018-01-05		[1.0, 1.	
↪ 1102230246251565e-16]		True					
1	src	constant	1	2018-01-01::2018-01-05	D	True	5.000000e+00 3.
↪ 000000	[2.]	FIT		src:1:D:2018-01-01::2018-01-05			
↪	[2.0]	False					

You can configure `run_forecast` to fit a seasonality model in addition to the trend model. To do so, include the argument `l_model_season` with a list of one or more seasonality models. If the list includes `model_null`, a non-seasonal model will also be fit and compared with the seasonal models. The function tries all combinations of trend models and seasonality models and selects the best:

```
df=pd.DataFrame({'y': np.full(21, 10.)+np.tile(np.arange(0., 7),3)},
                index=pd.date_range('2018-01-01', periods=21, freq='D'))
dict_result = forecast.run_forecast(df, extrapolate_years=0.5, simplify_output=False,
                                   l_model_trend = [forecast_models.model_linear,
                                                    forecast_models.model_constant],
                                   l_model_season = [forecast_models.model_null,
                                                    forecast_models.model_season_wday],
                                   # no seasonality model
                                   # weekday seasonality model
```

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```

include_all_fits=True)

print dict_result['data'].tail(6)
print dict_result['metadata'][['source', 'model', 'is_fit', 'cost', 'aic_c', 'params_str',
→ 'is_best_fit']]
    
```

Output:

```

.      date      model      y source      source_
→ long is_actuals is_weight is_filtered is_best_fit
2331 2019-01-16 (constant_mult_season_wday) 12.0 src src:1:D:2018-01-01::2018-
→ 01-21      False      False      False      False
2332 2019-01-17 (constant_mult_season_wday) 13.0 src src:1:D:2018-01-01::2018-
→ 01-21      False      False      False      False
2333 2019-01-18 (constant_mult_season_wday) 14.0 src src:1:D:2018-01-01::2018-
→ 01-21      False      False      False      False
2334 2019-01-19 (constant_mult_season_wday) 15.0 src src:1:D:2018-01-01::2018-
→ 01-21      False      False      False      False
2335 2019-01-20 (constant_mult_season_wday) 16.0 src src:1:D:2018-01-01::2018-
→ 01-21      False      False      False      False
2336 2019-01-21 (constant_mult_season_wday) 10.0 src src:1:D:2018-01-01::2018-
→ 01-21      False      False      False      False
    
```

```

. source      model is_fit      cost      aic_c
→      params_str is_best_fit
0 src      linear      True 3.741818e+01 16.130320
→      [ 0.1 11.9]      False
1 src      (linear_add_season_wday)      True 1.840127e-15 -742.442745 [3.5e-10 6.
→ 3e+00 3.7e+00 4.7e+00 5.7e+00 6.7e+...      False
2 src      constant      True 4.200000e+01 16.556091
→      [13.]      False
3 src      (constant_add_season_wday)      True 1.686607e-15 -750.272181 [12.
→ 7 -2.7 -1.7 -0.7 0.3 1.3 2.3 3.3]      False
4 src      (linear_mult_season_wday)      True 2.761458e-16 -782.272627 [-2.2e-10 1.
→ 9e+01 5.3e-01 5.9e-01 6.4e-01 ...      True
5 src      (constant_mult_season_wday)      True 6.833738e-13 -624.181393 [15.
→ 9 0.6 0.7 0.8 0.8 0.9 0.9 1. ]      False
    
```

The following trend and seasonality models are currently supported. They are available as attributes from *anticipy*. *forecast_models*:

Table 1: Default forecast models

name	params	formula	notes
model_null	0	y=0	Does nothing. Used to disable components (e.g. seasonality)
model_linear	2	y=Ax + B	Linear model
model_ramp	2	y = (x-A)*B if x>A	Ramp model
model_season_wday	6	see desc.	Weekday seasonality model. Assigns a constant value to each weekday
model_season_fourier_yearly	20	see desc	Fourier yearly seasonality model

Table 2: Other forecast models

name	params	formula	notes
model_constant	1	$y=A$	Constant model
model_linear_nondec	2	$y=Ax + B$	Non decreasing linear model. With boundaries to ensure model slope ≥ 0
model_quasilinear	3	$y=A*(x^B) + C$	Quasilinear model
model_exp	2	$y=A * B^x$	Exponential model
model_decay	4	$Y = A * e^{(B*(x-C))} + D$	Exponential decay model
model_step	2	$y=0$ if $x < A$, $y=B$ if $x \geq A$	Step model
model_two_steps	4	see model_step	2 step models. Parameter initialization is aware of # of steps.
model_sigmoid_step	3	$y = A + (B - A) / (1 + \text{np.exp}(- D * (x - C)))$	Sigmoid step model
model_sigmoid	3	$y = A + (B - A) / (1 + \text{np.exp}(- D * (x - C)))$	Sigmoid model
model_season_wday_2	2	see desc.	Weekend seasonality model. Assigns a constant to each of weekday/weekend
model_season_month	11	see desc.	Month seasonality model. Assigns a constant value to each month

If the available range of models isn't a good match for your data, it is also possible to define new models using `anticipy.forecast_models.ForecastModel`

3.5 Models with dummy variables

You can use `anticipy.forecast_models.get_model_dummy()` to get a model based on a dummy variable. This model returns a constant value when the dummy variable is 1, and 0 otherwise:

```
# Example dummy model - check if date matches specific dates in list
model_dummy_1_date = forecast_models.get_model_dummy('dummy_1_date', ['2017-12-22',
↪ '2017-12-27'])

# Example dummy model - checks if it is Christmas
model_dummy_christmas = forecast_models.get_model_dummy('dummy_christmas',
↪ lambda a_x, a_date: ((a_date.month == 12) &
↪ (a_date.day == 25)).astype(float))

a_x = np.arange(0,10)
a_date = pd.date_range('2017-12-21', '2017-12-30')
params = np.array([10.]) # A=10

print model_dummy_1_date(a_x, a_date, params)
print model_dummy_christmas(a_x, a_date, params)
```

Output:

```
[ 0. 10.  0.  0.  0.  0. 10.  0.  0.  0.]
[ 0.  0.  0.  0. 10.  0.  0.  0.  0.  0.]
```

Dummy variables can be very useful when used in composition with simpler models. A common application is to check for bank holidays or other special dates. The following example uses a dummy variable to improve fit in a linear

time series with a spike on Christmas:

```
df=pd.DataFrame({'y': 100+np.arange(0,6)+np.array([0.,0.,0.,0.,50.,0.,]),
                index=pd.date_range('2017-12-21','2017-12-26')})

# Example dummy model - checks if it is Christmas
model_dummy_christmas = forecast_models.get_model_dummy('dummy_christmas',
                lambda a_x, a_date: ((a_date.month == 12) &
                (a_date.day == 25)).astype(float))

dict_result = forecast.run_forecast(df, extrapolate_years=1, simplify_output=False,
                l_model_trend = [forecast_models.model_linear,
                forecast_models.model_linear+model_
                dummy_christmas],
                include_all_fits=True)

print dict_result['metadata'][['source','model','is_fit','cost','aic_c','params_str',
                'is_best_fit']]
```

Output:

.	source	is_best_fit	model	is_fit	cost	aic_c	
0	src	False	linear	True	8.809524e+02	37.935465	[5.3
1	src (linear_add_dummy_christmas)	True		True	9.980807e-20	-255.256784	[1. 100.

3.6 Outlier Detection

If you call `anticipy.forecast.run_forecast()` and specify as input `find_outliers=True`, it will try to automatically identify any outliers exist in the input Series. The weight for these samples is set to 0, so that they are ignored by the forecast logic.

Example:

```
a_y = [19.8, 19.9, 20.0, 20.1, 20.2, 20.3, 20.4, 20.5,
        20.6, 10., 20.7, 20.8, 20.9, 21.0,
        21.1, 21.2, 21.3, 21.4, 21.5]
a_date = pd.date_range(start='2018-01-01', periods=len(a_y), freq='D')
df_spike = pd.DataFrame({'y': a_y})

dict_result = forecast.run_forecast(df_spike, find_outliers=True,
                simplify_output=False, include_all_fits=True,
                season_add_mult='add')

df_data = dict_result['data']
# Subset of output - shows that the sample with a spike now has weight=0, and is_
# ignored by forecast
df_weighted_actuals = df_data.loc[df_data.model=='actuals'][['y','weight']]
```

Output:

.	y	weight
0	19.8	1.0
1	19.9	1.0
2	20.0	1.0

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3	20.1	1.0
4	20.2	1.0
5	20.3	1.0
6	20.4	1.0
7	20.5	1.0
8	20.6	1.0
9	10.0	0.0
10	20.7	1.0
11	20.8	1.0
12	20.9	1.0
13	21.0	1.0
14	21.1	1.0
15	21.2	1.0
16	21.3	1.0
17	21.4	1.0
18	21.5	1.0

LIBRARY REFERENCE

4.1 forecast

Functions to run forecast

`anticipy.forecast.get_residuals` (*params*, *model*, *a_x*, *a_y*, *a_date*, *a_weights=None*,
df_actuals=None, ***kwargs*)

Given a time series, a model function and a set of parameters, get the residuals

Parameters

- **params** (*numpy array of floats*) – parameters for model function
- **model** (*function or ForecastModel instance*) – model function. Usage: `model(a_x, a_date, params)`
- **a_x** (*numpy array of floats*) – X axis for model function.
- **a_y** (*numpy array of floats*) – Input time series values, to compare to the model function
- **a_date** (*numpy array of datetimes*) – Dates for the input time series
- **a_weights** (*numpy array of floats*) – weights for each individual sample
- **df_actuals** (*pandas DataFrame*) – The original dataframe with actuals data. Not required for regression but used by naive models

Returns array with residuals, same length as *a_x*, *a_y*

Return type *numpy array of floats*

`anticipy.forecast.optimize_least_squares` (*model*, *a_x*, *a_y*, *a_date*, *a_weights=None*,
df_actuals=None, *use_cache=True*)

Given a time series and a model function, find the set of parameters that minimises residuals

Parameters

- **model** (*function*) – model function, to be fitted against the actuals
- **a_x** (*numpy array of floats*) – X axis for model function.
- **a_y** (*numpy array of floats*) – Input time series values, to compare to the model function
- **a_date** (*numpy array of datetimes*) – Dates for the input time series
- **a_weights** (*numpy array of floats*) – weights for each individual sample
- **df_actuals** (*pandas DataFrame*) – The original dataframe with actuals data. Not required for regression but used by naive models

- **use_cache** (*bool*) – If true, save some model variables to cache when fitting

Returns

table(success, params, cost, optimality,
iterations, status, jac_evals, message):

- success (*bool*): True if successful fit
- params (*list*): Parameters of fitted model
- cost (*float*): Value of cost function
- optimality(*float*)
- iterations (*int*) : Number of function evaluations
- status (*int*) : Status code
- jac_evals(*int*) : Number of Jacobian evaluations
- message (*str*) : Output message

Return type pandas.DataFrame

```
anticipy.forecast.normalize_df(df_y, col_name_y='y', col_name_weight='weight',
                              col_name_x='x', col_name_date='date',
                              col_name_source='source')
```

Converts an input dataframe for run_forecast() into a normalized format suitable for fit_model()

Parameters

- **df_y** (*pandas.DataFrame*) – unformatted input dataframe, for use by run_forecast()
- **col_name_y** (*basestring*) – name for column with time series values
- **col_name_weight** (*basestring*) – name for column with time series weights
- **col_name_x** (*basestring*) – name for column with time series indices
- **col_name_date** (*basestring*) – name for column with time series dates
- **col_name_source** (*basestring*) – name for column with time series source identifiers

Returns formatted input dataframe, for use by run_forecast()

Return type pandas.DataFrame

```
anticipy.forecast.fit_model(model, df_y, freq='W', source='test', df_actuals=None,
                           use_cache=True)
```

Given a time series and a model, optimize model parameters and return

Parameters

- **model** (*function or ForecastModel instance*) – model function. Usage: model(a_x, a_date, params)
- **df_y** (*pandas.DataFrame*) –
Dataframe with the following columns:
 - y:
 - date: (optional)
 - weight: (optional)
 - x: (optional)

- **source** (*basestring*) – source identifier for this time series
- **freq** (*basestring*) – ‘W’ or ‘D’ . Used only for metadata
- **df_actuals** (*pandas DataFrame*) – The original dataframe with actuals data. Not required for regression but used by naive models
- **use_cache** (*bool*) – If true, save some model variables to cache when fitting

Returns table (source, model_name, y_weights , freq, is_fit, aic_c, params)

Return type pandas.DataFrame

This function calls `optimize_least_squares()` to perform the optimization loop. It performs some cleaning up of input and output parameters.

```
anticipy.forecast.extrapolate_model(model, params, date_start_actuals, date_end_actuals,
                                   freq='W', extrapolate_years=2.0, x_start_actuals=0.0,
                                   df_actuals=None)
```

Given a model and a set of parameters, generate model output for a date range plus a number of additional years.

Parameters

- **model** (*function or ForecastModel instance*) – model function. Usage: `model(a_x, a_date, params)`
- **params** (*numpy array of floats*) – parameters for model function
- **date_start_actuals** (*str, datetime, int or float*) – date or numeric index for first actuals sample
- **date_end_actuals** (*str, datetime, int or float*) – date or numeric index for last actuals sample
- **freq** (*basestring*) – Time unit between samples. Supported units are ‘W’ for weekly samples, or ‘D’ for daily samples. (untested) Any date unit or time unit accepted by numpy should also work, see <https://docs.scipy.org/doc/numpy-1.13.0/reference/arrays.datetime.html#arrays-dtypes-dateunits> # noqa
- **extrapolate_years** (*float*) – Number of years (or fraction of year) covered by the generated time series, after the end of the actuals
- **x_start_actuals** –
- **df_actuals** (*pandas DataFrame*) – The original dataframe with actuals data. Not required for regression but used by naive models

Returns dataframe with a time series extrapolated from the model function

Return type pandas.DataFrame, with an ‘y’ column of floats

```
anticipy.forecast.get_list_model(l_model_trend, l_model_season, season_add_mult='both')
```

Generate a list of composite models from lists of trend and seasonality models

Parameters

- **l_model_trend** (*list of ForecastModel*) – list of trend models
- **l_model_season** (*list of ForecastModel*) – list of seasonality models
- **season_add_mult** (*basestring*) – ‘mult’, ‘add’ or ‘both’, for multiplicative/additive composition (or both types)

Returns

Return type list of ForecastModel

All combinations of possible composite models are included

`anticipy.forecast.get_df_actuals_clean(df_actuals, source, source_long)`

Convert an actuals dataframe to a clean format

Parameters

- **df_actuals** (*pandas.DataFrame*) – dataframe in normalized format, with columns y and optionally x, date, weight
- **source** (*basestring*) – source identifier for this time series
- **source_long** (*basestring*) – long-format source identifier for this time series

Returns clean actuals dataframe

Return type *pandas.DataFrame*

`anticipy.forecast.run_forecast(df_y, l_model_trend=None, l_model_season=None, date_start_actuals=None, source_id='src', col_name_y='y', col_name_weight='weight', col_name_x='x', col_name_date='date', col_name_source='source', extrapolate_years=0, season_add_mult='add', include_all_fits=False, simplify_output=True, find_outliers=False, l_season_yearly=None, l_season_weekly=None, verbose=None, l_model_naive=None, l_model_calendar=None, n_cum=None, pi_q1=5, pi_q2=20, pi_widening_freq='Y', use_cache=True)`

Generate forecast for one or more input time series

Parameters

- **df_y** (*pandas.DataFrame*) – input dataframe with the following columns:
 - Mandatory: a value column, with the time series values
 - Optional: weight column, source ID column, index column, date column
- **l_model_trend** (*list of ForecastModel*) – list of trend models
- **l_model_season** (*list of ForecastModel*) – list of seasonality models
- **date_start_actuals** (*str, datetime, int or float*) – date or numeric index for first actuals sample to be used for forecast. Previous samples are ignored
- **source_id** (*basestring*) – source identifier for time series, if source column is missing
- **col_name_y** (*basestring*) – name for column with time series values
- **col_name_weight** (*basestring*) – name for column with time series weights
- **col_name_x** (*basestring*) – name for column with time series indices
- **col_name_date** (*basestring*) – name for column with time series dates
- **col_name_source** (*basestring*) – name for column with time series source identifiers
- **extrapolate_years** (*float*) – Number of years (or fraction of year) covered by the forecast, after the end of the actuals
- **season_add_mult** (*str*) – ‘add’, ‘mult’, or ‘both’. Whether forecast seasonality will be additive, multiplicative, or the best fit of the two.

- **find_outliers** (*bool*) – If True, find outliers in input data, ignore outlier samples in forecast
- **include_all_fits** (*bool*) – If True, also include non-optimal models in output
- **simplify_output** (*bool*) – If False, return dict with forecast and metadata. Otherwise, return only forecast.
- **l_season_yearly** (*list of ForecastModel*) – yearly seasonality models to consider in automatic seasonality detection
- **l_season_weekly** (*list of ForecastModel*) – yearly seasonality models to consider in automatic seasonality detection
- **verbose** (*bool*) – If True, enable verbose logging
- **l_model_naive** (*list of ForecastModel*) – list of naive models to consider for forecast. Naive models are not fitted with regression, they are based on the last actuals samples
- **l_model_calendar** (*list of ForecastModel*) – list of calendar models to consider for forecast, to handle holidays and calendar-based events
- **n_cum** (*int*) – Used for widening prediction interval. Interval widens every *n_sims* samples.
- **pi_q1** (*int*) – Percentile for outer prediction interval (defaults to 5%-95%)
- **pi_q2** (*int*) – Percentile for inner prediction interval (defaults to 20%-80%)
- **pi_widening_freq** (*str*) – Specifies the frequency with which the prediction interval widens: Y (yearly), M (monthly), W (weekly), D (daily). This parameters is deprecated - use `pi_widening_freq` instead
- **use_cache** (*bool*) – If true, save some model variables to cache when fitting

Returns

With `simplify_output=False`, returns a dictionary with 4 dataframes:

- forecast: output time series with prediction interval
- data: output time series. If `include_all_fits`, includes all fitting models
- metadata: forecast metadata table
- optimize_info: debugging metadata from `scipy.optimize`

With `simplify_output=True`, returns the ‘forecast’ dataframe, as described above

Return type `pandas.DataFrame` or dict of `pandas.DataFrames`

`anticipy.forecast.aggregate_forecast_dict_results` (*l_dict_result*)

Aggregates a list of dictionaries with forecast outputs into a single dictionary

Parameters `l_dict_result` (*list of dictionaries*) – list with outputs dictionaries from `run_forecast_single`

Returns aggregated dictionary

Return type dict

```
anticipy.forecast.run_forecast_single(df_y, l_model_trend=None, l_model_season=None,
                                     date_start_actuals=None, source_id='src', ex-
                                     trapolate_years=0, season_add_mult='add',
                                     include_all_fits=False, simplify_output=True,
                                     find_outliers=False, l_season_yearly=None,
                                     l_season_weekly=None, l_model_naive=None,
                                     l_model_calendar=None, n_cum=1,
                                     pi_q1=5, pi_q2=20, pi_widening_freq=None,
                                     use_cache=True)
```

Generate forecast for one input time series

Parameters

- **df_y** (*pandas.DataFrame*) – input dataframe with the following columns:
 - y: time series values
 - x: time series indices
 - weight: time series weights (optional)
 - date: time series dates (optional)
- **l_model_trend** (*list of ForecastModel*) – list of trend models
- **l_model_season** (*list of ForecastModel*) – list of seasonality models
- **date_start_actuals** (*str, datetime, int or float*) – date or numeric index for first actuals sample to be used for forecast. Previous samples are ignored
- **source_id** (*basestring*) – source identifier for time series
- **extrapolate_years** (*float*) –
- **season_add_mult** (*str*) – ‘add’, ‘mult’, or ‘both’. Whether forecast seasonality will be additive, multiplicative, or the best fit of the two.
- **include_all_fits** (*bool*) – If True, also include non-optimal models in output
- **simplify_output** (*bool*) – If False, return dict with forecast and metadata. Otherwise, return only forecast.
- **find_outliers** (*bool*) – If True, find outliers in input data, ignore outlier samples in forecast
- **l_season_yearly** (*list of ForecastModel*) – yearly seasonality models to consider in automatic seasonality detection
- **l_season_weekly** (*list of ForecastModel*) – yearly seasonality models to consider in automatic seasonality detection
- **l_model_naive** (*list of ForecastModel*) – list of naive models to consider for forecast. Naive models are not fitted with regression, they are based on the last actuals samples
- **l_model_calendar** (*list of ForecastModel*) – list of calendar models to consider for forecast, to handle holidays and calendar-based events
- **n_cum** (*int*) – Used for widening prediction interval. Interval widens every n_sims samples. This parameters is deprecated - use pi_widening_freq instead
- **pi_q1** (*int*) – Percentile for outer prediction interval (defaults to 5%-95%)
- **pi_q2** (*int*) – Percentile for inner prediction interval (defaults to 20%-80%)

- **widening_freq** – Specifies the frequency with which the prediction interval widens: Y (yearly), M (monthly), W (weekly), D (daily).
- **use_cache** (*bool*) – If true, save some model variables to cache when fitting

Returns

With `simplify_output=False`, returns a dictionary with 4 dataframes:

- `forecast`: output time series with prediction interval
- `data`: output time series. If `include_all_fits`, includes all fitting models
- `metadata`: forecast metadata table
- `optimize_info`: debugging metadata from `scipy.optimize`

With `simplify_output=True`, returns the ‘forecast’ dataframe, as described above

Return type `pandas.DataFrame` or dict of `pandas.DataFrames`

```
anticipy.forecast.run_1_forecast(l_fcast_input, col_name_y='y', col_name_weight='weight',
                                col_name_x='x', col_name_date='date',
                                col_name_source='source', extrapolate_years=0,
                                season_add_mult='add', include_all_fits=False,
                                find_outliers=False, use_cache=True)
```

Generate forecasts for a list of `SolverConfig` objects, each including a time series, model functions, and other configuration parameters.

Parameters

- **l_fcast_input** (*list of ForecastInput*) – List of forecast input configurations. Each element includes a time series, candidate forecast models for trend and seasonality, and other configuration parameters. For each input configuration, a forecast time series will be generated.
- **return_all_models** (*bool*) –
If True, result includes non-fitting models, with null AIC and an empty forecast df. Otherwise, result includes only fitting models, and for time series where no fitting model is available, a ‘no-best-model’ entry with null AIC and an empty forecast df is added.
- **return_all_fits** (*bool*) – If True, result includes all models for each input time series. Otherwise, only the best model is included.
- **extrapolate_years** (*float*) –
- **season_add_mult** (*str*) – ‘add’, ‘mult’, or ‘both’. Whether forecast seasonality will be additive, multiplicative, or the best fit of the two.
- **fill_gaps_y_values** (*bool*) – If True, gaps in time series will be filled with NaN values
- **freq** (*str*) – ‘W’ or ‘D’. Sampling frequency of the output forecast: weekly or daily.
- **use_cache** (*bool*) – If true, save some model variables to cache when fitting

Returns

```
dict(data,metadata)
data: dataframe(date, source, model, y)
metadata: dataframe('source', 'model', 'res_weights', 'freq',
'is_fit', 'cost', 'aic_c', 'params', 'status')
```

Return type dict

```
class anticipy.forecast.ForecastInput (source_id, df_y, l_model_trend=None,
l_model_season=None, weights_y_values=1.0,
date_start_actuals=None)
```

Class that encapsulates input variables for forecast.run_forecast()

```
anticipy.forecast.get_pi (df_forecast, n_sims=100, n_cum=None, pi_q1=5, pi_q2=20, widening_freq='Y')
```

Generate prediction intervals for a table with multiple forecasts, using bootstrapped residuals.

Parameters

- **df_forecast** (*pandas.DataFrame*) – forecasted time series
- **n_sims** (*int*) – Number of bootstrapped samples for prediction interval
- **n_cum** (*int*) – Used for widening prediction interval. Interval widens every n_sims samples. This parameters is deprecated - use widening_freq instead
- **pi_q1** (*int*) – Percentile for outer prediction interval (defaults to 5%-95%)
- **pi_q2** (*int*) – Percentile for inner prediction interval (defaults to 20%-80%)
- **widening_freq** (*str*) – Specifies the frequency with which the prediction interval widens: Y (yearly), M (monthly), W (weekly), D (daily).

Returns

Forecast time series table with added columns:

- q5: 5% percentile of prediction interval
- q5: 20% percentile of prediction interval
- q5: 80 percentile of prediction interval
- q5: 95% percentile of prediction interval

Return type pandas.DataFrame

Based on <https://otexts.org/fpp2/prediction-intervals.html>

4.2 forecast_models

Defines the ForecastModel class, which encapsulates model functions used in forecast model fitting, as well as their number of parameters and initialisation parameters.

```
class anticipy.forecast_models.ForecastModel (name,          n_params,          f_model,
                                             f_init_params=None,  f_bounds=None,
                                             l_f_validate_input=None,
                                             l_cache_vars=None, dict_f_cache=None)
```

Class that encapsulates model functions for use in forecasting, as well as their number of parameters and functions for parameter initialisation.

A ForecastModel instance is initialized with a model name, a number of model parameters, and a model function. Class instances are callable - when called as a function, their internal model function is used. The main purpose of ForecastModel objects is to generate predicted values for a time series, given a set of parameters. These values can be compared to the original series to get an array of residuals:

```
y_predicted = model(a_x, a_date, params)
residuals = (a_y - y_predicted)
```

This is used in an optimization loop to obtain the optimal parameters for the model.

The reason for using this class instead of raw model functions is that ForecastModel supports function composition:

```
model_sum = fcast_model1 + fcast_model2
# fcast_model 1 and 2 are ForecastModel instances, and so is model_sum
a_y1 = fcast_model1(
    a_x, a_date, params1) + fcast_model2(a_x, a_date, params2)
params = np.concatenate([params1, params2])
a_y2 = model_sum(a_x, a_date, params)
a_y1 == a_y2 # True
```

Forecast models can be added or multiplied, with the + and * operators. Multiple levels of composition are supported:

```
model = (model11 + model12) * model13
```

Model composition is used to aggregate trend and seasonality model components, among other uses.

Model functions have the following signature:

- `f(a_x, a_date, params, is_mult)`
- `a_x` : array of floats
- `a_date`: array of dates, same length as `a_x`. Only required for date-aware models, e.g. for weekly seasonality.
- `params`: array of floats - model parameters - the optimisation loop updates this to fit our actual values. Each model function uses a fixed number of parameters.
- `is_mult`: boolean. True if the model is being used with multiplicative composition. Required because some model functions (e.g. steps) have different behaviour when added to other models than when multiplying them.
- returns an array of floats - with same length as `a_x` - output of the model defined by this object's modelling function `f_model` and the current set of parameters

By default, model parameters are initialized as random values between 0 and 1. It is possible to define a parameter initialization function that picks initial values based on the original time series. This is passed during ForecastModel creation with the argument `f_init_params`. Parameter initialization is compatible with model composition: the initialization function of each component will be used for that component's parameters.

Parameter initialisation functions have the following signature:

- `f_init_params(a_x, a_y, is_mult)`
- `a_x`: array of floats - same length as time series
- `a_y`: array of floats - time series values
- returns an array of floats - with length equal to this object's `n_params` value

By default, model parameters have no boundaries. However, it is possible to define a boundary function for a model, that sets boundaries for each model parameter, based on the input time series. This is passed during ForecastModel creation with the argument `f_bounds`. Boundary definition is compatible with model composition: the boundary function of each component will be used for that component's parameters.

Boundary functions have the following signature:

- `f_bounds(a_x, a_y, a_date)`
- `a_x`: array of floats - same length as time series
- `a_y`: array of floats - time series values
- `a_date`: array of dates, same length as `a_x`. Only required for date-aware models, e.g. for weekly seasonality.
- returns a tuple of 2 arrays of floats. The first defines minimum parameter boundaries, and the second the maximum parameter boundaries.

As an option, we can assign a list of input validation functions to a model. These functions analyse the inputs that will be used for fitting a model, returning True if valid, and False otherwise. The forecast logic will skip a model from fitting if any of the validation functions for that model returns False.

Input validation functions have the following signature:

- `f_validate_input(a_x, a_y, a_date)`
- See the description of model functions above for more details on these parameters.

Our input time series should meet the following constraints:

- Minimum required samples depends on number of model parameters
- May include null values
- May include multiple values per sample
- A date array is only required if the model is date-aware

Class Usage:

```
model_x = ForecastModel(name, n_params, f_model, f_init_params,
l_f_validate_input)
# Get model name
model_name = model_x.name
# Get number of model parameters
n_params = model_x.n_params
# Get parameter initialisation function
f_init_params = model_x.f_init_params
# Get initial parameters
```

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```

init_params = f_init_params(t_values, y_values)
# Get model fitting function
f_model = model_x.f_model
# Get model output
y = f_model(a_x, a_date, parameters)
    
```

The following pre-generated models are available. They are available as attributes from this module: # noqa

Table 1: Forecast models

name	params	formula	notes
model_null	0	$y=0$	Does nothing. Used to disable components (e.g. seasonality)
model_constant	1	$y=A$	Constant model
model_linear	2	$y=Ax + B$	Linear model
model_linear_nondec	2	$y=Ax + B$	Non decreasing linear model. With boundaries to ensure model slope ≥ 0
model_quasilinear	3	$y=A*(x^B) + C$	Quasilinear model
model_exp	2	$y=A * B^x$	Exponential model
model_decay	4	$Y = A * e^{(B*(x-C))} + D$	Exponential decay model
model_step	2	$y=0$ if $x < A$, $y=B$ if $x \geq A$	Step model
model_two_steps	4	see model_step	2 step models. Parameter initialization is aware of # of steps.
model_sigmoid_step	3	$y = A + (B - A) / (1 + \text{np.exp}(- D * (x - C)))$	Sigmoid step model
model_sigmoid	3	$y = A + (B - A) / (1 + \text{np.exp}(- D * (x - C)))$	Sigmoid model
model_season_wday	7	see desc.	Weekday seasonality model. Assigns a constant value to each weekday
model_season_wday	6	see desc.	6-param weekday seasonality model. As above, with one constant set to 0.
model_season_wday_2	2	see desc.	Weekend seasonality model. Assigns a constant to each of weekday/weekend
model_season_month	12	see desc.	Month seasonality model. Assigns a constant value to each month
model_season_fourier_yearly	4	see desc	Fourier yearly seasonality model

`anticipy.forecast_models.get_model_outliers(df, window=3)`

Identify outlier samples in a time series

Parameters

- **df** (*pandas.DataFrame*) – Input time series
- **window** (*int*) – The x-axis window to aggregate multiple steps/spikes

Returns

tuple (mask_step, mask_spike)
 mask_step: True if sample contains a step
 mask_spike: True if sample contains a spike

Return type tuple of 2 numpy arrays of booleans

TODO: require minimum number of samples to find an outlier

`anticipy.forecast_models.get_model_dummy(name, dummy, **kwargs)`

Generate a model based on a dummy variable.

Parameters

- **name** (*basestring*) – Name of the model
- **dummy** (*function, or list-like of numerics or datetime-likes*) –

Can be a function or a list-like.

If a function, it must be of the form `f_dummy(a_x, a_date)`,

and return a numpy array of floats

with the same length as `a_x` and values that are either 0 or 1.

If a list-like of numerics, it will be converted to a `f_dummy` function

as described above, which will have values of 1 when `a_x` has one of the values in the list, and 0 otherwise. If a list-like of date-likes,

it will be converted to a `f_dummy` function as described above, which will have values of 1 when `a_date` has one of the values in the list, and 0 otherwise.

- **kwargs** –

Returns

A model that returns A when dummy is 1, and 0 (or 1 if `is_mult==True`) otherwise.

Return type *ForecastModel*

class `anticipy.forecast_models.CalendarBankHolUK` (*name=None, rules=None*)

class `anticipy.forecast_models.CalendarChristmasUK` (*name=None, rules=None*)

class `anticipy.forecast_models.CalendarBankHolIta` (*name=None, rules=None*)

class `anticipy.forecast_models.CalendarChristmasIta` (*name=None, rules=None*)

`anticipy.forecast_models.get_model_from_calendars(l_calendar, name=None)`

Create a ForecastModel based on a list of pandas Calendars.

Parameters **calendar** (*pandas.tseries.AbstractHolidayCalendar*) –

Returns model based on the input calendar

Return type *ForecastModel*

In pandas, Holidays and calendars provide a simple way to define holiday rules, to be used in any analysis that requires a predefined set of holidays. This function converts a Calendar object into a ForecastModel that assigns a parameter to each calendar rule.

As an example, a Calendar with 1 rule defining Christmas dates generates a model with a single parameter, which determines the amount added/multiplied to samples falling on Christmas. A calendar with 2 rules for Christmas and New Year will have two parameters - the first one applying to samples in Christmas, and the second one applying to samples in New Year.

Usage:

```
from pandas.tseries.holiday import USFederalHolidayCalendar
model_calendar = get_model_from_calendar(USFederalHolidayCalendar())
```

`anticipy.forecast_models.get_model_from_datalist` (*name=None, *args*)

Create a ForecastModel based on one or more lists of dates.

Parameters

- **name** (*str*) – Model name
- **args** – Each element in args is a list of dates.

Returns model based on the input lists of dates

Return type *ForecastModel*

Usage:

```
model_datalist1=get_model_from_date_list('datalist1',
                                         [date1, date2, date3])
model_datalists23 = get_model_from_date_list('datalists23',
                                             [date1, date2], [date3, date4])
```

In the example above, `model_datalist1` will have one parameter, which determines the amount added/multiplied to samples with dates matching either `date1`, `date2` or `date3`. `model_datalists23` will have two parameters - the first one applying to samples in `date1` and `date2`, and the second one applying to samples in `date3` and `date4`

`anticipy.forecast_models.fix_params_fmodel` (*forecast_model, l_params_fixed*)

Given a forecast model and a list of floats, modify the model so that some of its parameters become fixed

Parameters

- **forecast_model** (*ForecastModel*) – Input model
- **l_params_fixed** (*list*) – List of floats with same length as number of parameters in model. For each element, a non-null value means that the parameter in that position is fixed to that value. A null value means that the parameter in that position is not fixed.

Returns A forecast model with a number of parameters equal to the number of null values in `l_params_fixed`, with `f_model` modified so that some of its parameters gain fixed values equal to the non-null values in `l_params`

Return type *ForecastModel*

`anticipy.forecast_models.simplify_model` (*f_model, a_x=None, a_y=None, a_date=None*)

Check a model's bounds, and update model to make parameters fixed if their min and max bounds are equal

Parameters

- **f_model** (*ForecastModel*) – Input model
- **a_x** (*numpy array of floats*) – X axis for model function.
- **a_y** (*numpy array of floats*) – Input time series values, to compare to the model function
- **a_date** (*numpy array of datetimes*) – Dates for the input time series

Returns Model with simplified parameters based on bounds

Return type *ForecastModel*

```
anticipy.forecast_models.get_1_model_auto_season(a_date, min_periods=1.5,
                                                season_add_mult='add',
                                                l_season_yearly=None,
                                                l_season_weekly=None)
```

Generates a list of candidate seasonality models for an series of timestamps

Parameters

- **a_date** (*numpy array of timestamps*) – date array of a time series
- **min_periods** (*float*) – Minimum number of periods required to apply seasonality
- **season_add_mult** – ‘add’ or ‘mult’

Returns list of candidate seasonality models

Return type list of ForecastModel

4.3 model_utils

Utility functions for model generation

```
anticipy.model_utils.array_transpose(a)
Transpose a 1-D numpy array
```

Parameters **a** (*numpy.Array*) – An array with shape (n,)

Returns The original array, with shape (n,1)

Return type numpy.Array

```
anticipy.model_utils.model_requires_scaling(model)
```

Given a *anticipy.forecast_models.ForecastModel* return True if the function requires scaling **a_x**

Parameters **model** (*function or None*) – A `get_model<modeltype>` function from `anticipy.model.periodic_models` or `anticipy.model.aperiodic_models`

Returns True if function is logistic or sigmoidal

Return type bool

```
anticipy.model_utils.apply_a_x_scaling(a_x, model=None, scaling_factor=100.0)
Modify a_x for forecast_models that require it
```

Parameters

- **a_x** (*numpy array*) – x axis of time series
- **model** (*function or None*) – a `anticipy.forecast_models.ForecastModel`
- **scaling_factor** (*float*) – Value used for scaling t_values for logistic models

Returns a_x with scaling applied, if required

Return type numpy array

```
anticipy.model_utils.get_normalized_x_from_date(s_date)
Get column of days since Monday of first date
```

```
anticipy.model_utils.get_s_x_extrapolate(date_start_actuals, date_end_actuals,
                                         model=None, freq='W', extrapolate_years=2.5,
                                         shifted_origin=0, scaling_factor=100.0,
                                         x_start_actuals=0.0)
```

Return a_x series with DateTimeIndex, covering the date range for the actuals, plus a forecast period.

Parameters

- **date_start_actuals** (*str, datetime, int or float*) – date or numeric index for first actuals sample
- **date_end_actuals** (*str, datetime, int or float*) – date or numeric index for last actuals sample
- **extrapolate_years** (*float*) –
- **model** (*function*) –
- **freq** (*basestring*) – Time unit between samples. Supported units are ‘W’ for weekly samples, or ‘D’ for daily samples. (untested) Any date unit or time unit accepted by numpy should also work, see <https://docs.scipy.org/doc/numpy-1.13.0/reference/arrays.datetime.html#arrays-dtypes-dateunits> # noqa
- **shifted_origin** (*int*) – Offset to apply to a_x
- **scaling_factor** (*float*) – Value used for scaling a_x for certain model functions

Returns Series of floats with DateTimeIndex. To be used as (a_date, a_x) input for a model function.

Return type pandas.Series

The returned series covers the actuals time domain plus a forecast period lasting `extrapolate_years`, in years. The number of additional samples for the forecast period is `time_resolution * extrapolate_years`, rounded down

```
anticipy.model_utils.get_aic_c(fit_error, n, n_params)
```

This function implements the corrected Akaike Information Criterion (AICc) taking as input a given fit error and data/model degrees of freedom. We assume that the residuals of the candidate model are distributed according to independent identical normal distributions with zero mean. Hence, we can use define the AICc as

$$AICc = AIC + \frac{2k(k+1)}{n-k-1} = 2k + n \log \left(\frac{E}{n} \right) + \frac{2k(k+1)}{n-k-1},$$

where *k* and *n* denotes the model and data degrees of freedom respectively, and *E* denotes the residual error of the fit.

Parameters

- **fit_error** (*float*) – Residual error of the fit
- **n** (*int*) – Data degrees of freedom
- **n_params** (*int*) – Model degrees of freedom

Returns Corrected Akaike Information Criterion (AICc)

Return type float

Note:

- see AIC in [Wikipedia article on the AIC](#).

`anticipy.model_utils.is_multiplicative(df, freq='M')`

For an input time series, check if model composition should be multiplicative.

Return True if multiplicative is best - otherwise, use additive composition.

We assume multiplicative composition is best if variance correlates heavily (>0.8) with mean. We aggregate data on a monthly basis by default for this analysis. Use

The following exceptions apply:

- If any time series value is <=0, use additive
- If date information is unavailable (only x column), use additive
- If less than 2 periods worth of data are available, use additive

4.4 forecast_plot

Functions to plot forecast outputs

`anticipy.forecast_plot.plot_forecast(df_fcast, output='html', path=None, width=None, height=None, title=None, dpi=70, show_legend=True, auto_open=False, include_interval=False, pi_q1=5, pi_q2=20)`

Generates matplotlib or plotly plot and saves it respectively as png or html

Parameters

- **df_fcast** (*pandas.DataFrame*) – Forecast Dataframe with the following columns:
 - date (timestamp)
 - model (str) : ID for the forecast model
 - y (float) : Value of the time series in that sample
 - is_actuals (bool) : True for actuals samples, False for forecast
- **output** (*basestring*) – Indicates the output type (html=Default, png or jupyter)
- **path** (*basestring*) – File path for output
- **width** (*int*) – Image width, in pixels
- **height** (*int*) – Image height, in pixels
- **title** (*basestring*) – Plot title
- **dpi** (*int*) – Image dpi
- **show_legend** (*bool*) – Indicates whether legends will be displayed
- **auto_open** (*bool*) – Indicates whether the output will be displayed automatically
- **pi_q1** (*int*) – Percentile for outer prediction interval (defaults to 5%-95%)
- **pi_q2** (*int*) – Percentile for inner prediction interval (defaults to 20%-80%)

Returns Success or failure code.

Return type int

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