Weather Prediction using Prophet

Overview

Predicting New York City maximum temperature using JFK International Airport Station data from sourced from NOOA.

In [1]:
```
# Library import
import warnings
warnings.filterwarnings('ignore')

import pandas as pd
import numpy as np
```

In [2]:
```
# Loading data
weather = pd.read_csv("jfk_weather.csv", index_col="DATE")
```

The five core weather values are:

```
PRCP = Precipitation (mm or inches )
SNOW = Snowfall (mm or inches )
SNWD = Snow depth (mm or inches )
TMAX = Maximum temperature (Fahrenheit or Celsius as per user preference)
TMIN = Minimum temperature (Fahrenheit or Celsius as per user preference)
```

In [3]:
```
# View DataFrame
weather
```

Out[3]:

DATE	STATION	NAME	ACMH	ACSH	AWND	FMTM	PGTM	PRCP	SNOW	SNWD	...	WT
1970-01-01	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	80.0	90.0	NaN	NaN	NaN	0.00	0.0	0.0	...	N
1970-01-02	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	30.0	20.0	NaN	NaN	NaN	0.00	0.0	0.0	...	N
1970-01-03	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	80.0	100.0	NaN	NaN	NaN	0.02	0.0	0.0	...	N
1970-01-04	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	10.0	20.0	NaN	NaN	NaN	0.00	0.0	0.0	...	N
1970-01-05	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	30.0	10.0	NaN	NaN	NaN	0.00	0.0	0.0	...	N
...	...	...	...	...	...	...	...	...	...	...	...	
2022-11-14	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	NaN	NaN	12.97	NaN	NaN	0.00	0.0	0.0	...	N
2022-11-15	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	NaN	NaN	11.18	NaN	NaN	0.43	0.0	0.0	...	N
2022-11-16	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	NaN	NaN	17.22	NaN	NaN	0.20	0.0	0.0	...	N
2022-11-17	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	NaN	NaN	17.67	NaN	NaN	0.00	0.0	0.0	...	N
2022-11-18	USW00094789	JFK INTERNATIONAL AIRPORT, NY US	NaN	NaN	17.45	NaN	2020.0	0.01	0.0	0.0	...	N

19315 rows × 44 columns

In [4]:
```
# Info about weather
weather.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 19315 entries, 1970-01-01 to 2022-11-18
Data columns (total 44 columns):
 #   Column   Non-Null Count  Dtype  
---  ------   --------------  -----  
 0   STATION  19315 non-null  object 
 1   NAME     19315 non-null  object 
 2   ACMH     9615 non-null   float64
 3   ACSH     9616 non-null   float64
 4   AWND     14200 non-null  float64
 5   FMTM     10124 non-null  float64
 6   PGTM     12269 non-null  float64
 7   PRCP     19315 non-null  float64
 8   SNOW     19315 non-null  float64
 9   SNWD     19314 non-null  float64
 10  TAVG     6192 non-null   float64
 11  TMAX     19315 non-null  int64  
 12  TMIN     19315 non-null  int64  
 13  TSUN     31 non-null     float64
 14  WDF1     9611 non-null   float64
 15  WDF2     9698 non-null   float64
 16  WDF5     9615 non-null   float64
 17  WDFG     5121 non-null   float64
 18  WDFM     1 non-null      float64
 19  WESD     6071 non-null   float64
 20  WSF1     9614 non-null   float64
 21  WSF2     9698 non-null   float64
 22  WSF5     9614 non-null   float64
 23  WSFG     7463 non-null   float64
 24  WSFM     1 non-null      float64
 25  WT01     7144 non-null   float64
 26  WT02     1256 non-null   float64
 27  WT03     1287 non-null   float64
 28  WT04     336 non-null    float64
 29  WT05     364 non-null    float64
 30  WT06     181 non-null    float64
 31  WT07     108 non-null    float64
 32  WT08     3918 non-null   float64
 33  WT09     140 non-null    float64
 34  WT11     14 non-null     float64
 35  WT13     2185 non-null   float64
 36  WT14     887 non-null    float64
 37  WT15     42 non-null     float64
 38  WT16     6577 non-null   float64
 39  WT17     60 non-null     float64
 40  WT18     1167 non-null   float64
 41  WT21     5 non-null      float64
 42  WT22     49 non-null     float64
 43  WV01     1 non-null      float64
dtypes: float64(40), int64(2), object(2)
memory usage: 6.6+ MB
```

In [5]:
```
# Clean invalid columns
null_pct = weather.apply(pd.isnull).sum()/weather.shape[0]
null_pct
```

Out[5]:
```
STATION    0.000000
NAME       0.000000
ACMH       0.502200
ACSH       0.502149
AWND       0.264820
FMTM       0.475848
PGTM       0.364794
PRCP       0.000000
SNOW       0.000000
SNWD       0.000052
TAVG       0.679420
TMAX       0.000000
TMIN       0.000000
TSUN       0.998395
WDF1       0.502407
WDF2       0.497903
WDF5       0.502200
WDFG       0.734869
WDFM       0.999948
WESD       0.685685
WSF1       0.502252
WSF2       0.497903
WSF5       0.502252
WSFG       0.613616
WSFM       0.999948
WT01       0.630132
WT02       0.934973
WT03       0.933368
WT04       0.982604
WT05       0.981155
WT06       0.990629
WT07       0.994408
WT08       0.797152
WT09       0.992752
WT11       0.999275
WT13       0.886875
WT14       0.954077
WT15       0.997826
WT16       0.659487
WT17       0.996894
WT18       0.939581
WT21       0.999741
WT22       0.997463
WV01       0.999948
dtype: float64
```

In [6]:
```
# Choosing features
valid_columns = weather.columns[null_pct < .05]
valid_columns
```

Out[6]:
```
Index(['STATION', 'NAME', 'PRCP', 'SNOW', 'SNWD', 'TMAX', 'TMIN'], dtype='object')
```

In [7]:
```
# Distinct categories of 'NAME' column
weather.STATION.unique(), weather['NAME'].unique()
```

Out[7]:
```
(array(['USW00094789'], dtype=object),
 array(['JFK INTERNATIONAL AIRPORT, NY US'], dtype=object))
```

In [8]:
```
# Choosing columns to use
core_weather = weather[['PRCP', 'SNOW', 'SNWD', 'TMIN','TMAX']].copy()
# Changing column names
core_weather.columns = ['precipitation', 'snow', 'snow_depth', 'min_temp', 'max_temp']
```

In [9]:
```
core_weather.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 19315 entries, 1970-01-01 to 2022-11-18
Data columns (total 5 columns):
 #   Column         Non-Null Count  Dtype  
---  ------         --------------  -----  
 0   precipitation  19315 non-null  float64
 1   snow           19315 non-null  float64
 2   snow_depth     19314 non-null  float64
 3   min_temp       19315 non-null  int64  
 4   max_temp       19315 non-null  int64  
dtypes: float64(3), int64(2)
memory usage: 905.4+ KB
```

In [10]:
```
# Data type of the index
core_weather.index.dtype
```

Out[10]:
```
dtype('O')
```

In [11]:
```
# Changing data type to datetime
core_weather.index = pd.to_datetime(weather.index)
```

In [12]:
```
core_weather.index.dtype
```

Out[12]:
```
dtype('<M8[ns]')
```

In [13]:
```
# Look at first 5 rows
core_weather.head()
```

Out[13]:

DATE	precipitation	snow	snow_depth	min_temp	max_temp
1970-01-01	0.00	0.0	0.0	22	28
1970-01-02	0.00	0.0	0.0	22	31
1970-01-03	0.02	0.0	0.0	25	38
1970-01-04	0.00	0.0	0.0	23	31
1970-01-05	0.00	0.0	0.0	21	35

In [14]:
```
# Check for missing value defined in data documentation
core_weather.apply(lambda x: (x == 9999).sum())
```

Out[14]:
```
precipitation    0
snow             0
snow_depth       0
min_temp         0
max_temp         0
dtype: int64
```

In [15]:
```
# Check for missing values
core_weather.apply(pd.isnull).sum()
```

Out[15]:
```
precipitation    0
snow             0
snow_depth       1
min_temp         0
max_temp         0
dtype: int64
```

In [16]:
```
# Values counts of 'snow_depth'
core_weather["snow_depth"].value_counts()
```

Out[16]:
```
0.0     18342
1.0       223
2.0       189
3.0        98
4.0        61
1.2        50
6.0        46
5.0        44
7.0        27
8.0        26
5.1        21
9.0        18
3.1        17
7.1        17
11.0       15
10.0       13
3.9        13
5.9        13
7.9        12
9.1        11
12.0       11
14.0        9
9.8         8
13.0        5
17.0        4
19.0        3
16.0        3
22.0        3
15.0        2
26.0        2
28.0        2
18.0        2
21.0        2
23.0        1
11.8        1
Name: snow_depth, dtype: int64
```

In [17]:
```
# Median of 'snow_depth'
core_weather['snow_depth'].median()
```

Out[17]:
```
0.0
```

In [18]:
```
# Mean of 'snow_depth'
core_weather['snow_depth'].mean()
```

Out[18]:
```
0.20933001967484727
```

In [19]:
```
# Filling in missing values
core_weather['snow_depth'] = core_weather['snow_depth'].fillna(0.0)
```

In [20]:
```
# Re check missing values
core_weather.apply(pd.isnull).sum()
```

Out[20]:
```
precipitation    0
snow             0
snow_depth       0
min_temp         0
max_temp         0
dtype: int64
```

In [21]:
```
core_weather.head()
```

Out[21]:

DATE	precipitation	snow	snow_depth	min_temp	max_temp
1970-01-01	0.00	0.0	0.0	22	28
1970-01-02	0.00	0.0	0.0	22	31
1970-01-03	0.02	0.0	0.0	25	38
1970-01-04	0.00	0.0	0.0	23	31
1970-01-05	0.00	0.0	0.0	21	35

In [22]:
```
# Setup time series for prophet
core_weather['y'] = core_weather.shift(-1)['max_temp']
```

In [23]:
```
# Forward filling in
core_weather = core_weather.ffill()
```

In [24]:
```
core_weather["ds"] = core_weather.index
```

In [25]:
```
core_weather.shape
```

Out[25]:
```
(19315, 7)
```

In [26]:
```
# Define predicting features
predictors = core_weather.columns[~core_weather.columns.isin(["y", "precipitation", "sn
```

In [27]:
```
core_weather
```

Out[27]:

DATE	precipitation	snow	snow_depth	min_temp	max_temp	y	ds
1970-01-01	0.00	0.0	0.0	22	28	31.0	1970-01-01
1970-01-02	0.00	0.0	0.0	22	31	38.0	1970-01-02
1970-01-03	0.02	0.0	0.0	25	38	31.0	1970-01-03
1970-01-04	0.00	0.0	0.0	23	31	35.0	1970-01-04
1970-01-05	0.00	0.0	0.0	21	35	36.0	1970-01-05
...	...	...	...	...	...	...	...
2022-11-14	0.00	0.0	0.0	35	47	46.0	2022-11-14
2022-11-15	0.43	0.0	0.0	33	46	53.0	2022-11-15
2022-11-16	0.20	0.0	0.0	41	53	47.0	2022-11-16
2022-11-17	0.00	0.0	0.0	38	47	46.0	2022-11-17
2022-11-18	0.01	0.0	0.0	35	46	46.0	2022-11-18

19315 rows × 7 columns

In [28]:
```
# Splitting into train and test
train = core_weather[:"2021-12-31"]
test = core_weather["2021-12-31":]
```

In [29]:
```
# Fit initial prophet model
from prophet import Prophet

def fit_prophet(train):
    m = Prophet()
    for p in predictors:
        m.add_regressor(p)
    m.fit(train)
    return m

m = fit_prophet(train)
```

```
14:59:31 - cmdstanpy - INFO - Chain [1] start processing
15:00:03 - cmdstanpy - INFO - Chain [1] done processing
```

In [30]:
```
# Make predictions
predictions = m.predict(test)
```

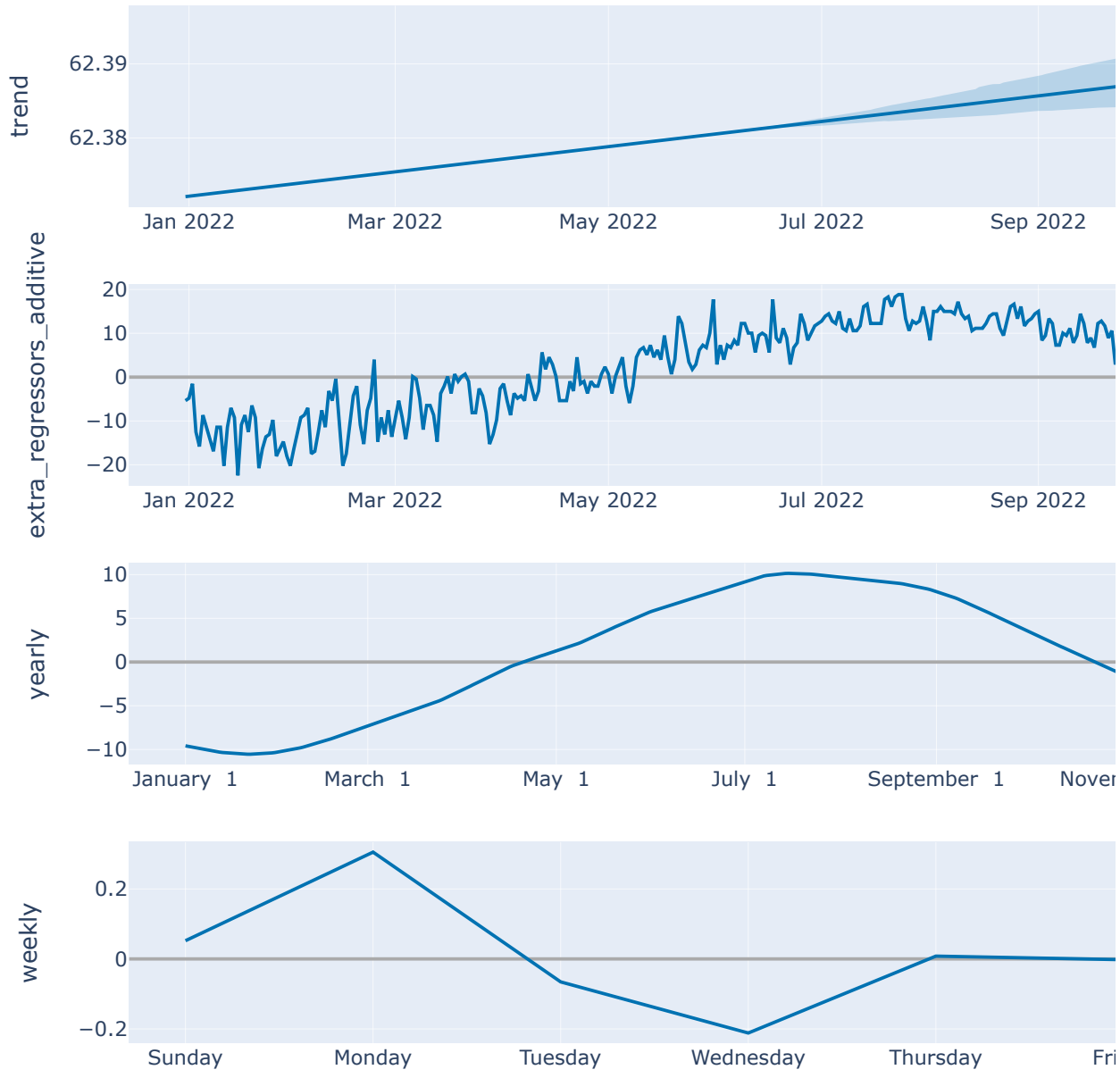
In [31]:
```
predictions
```

Out[31]:

	ds	trend	yhat_lower	yhat_upper	trend_lower	trend_upper	additive_terms	additive_terms_low
0	2021-12-31	62.372073	39.852048	55.700393	62.372073	62.372073	-14.858824	-14.8588
1	2022-01-01	62.372129	39.922782	55.962413	62.372129	62.372129	-14.470782	-14.4707
2	2022-01-02	62.372184	43.311876	59.558708	62.372184	62.372184	-11.108334	-11.1083
3	2022-01-03	62.372240	32.587321	49.082129	62.372240	62.372240	-21.938245	-21.9382
4	2022-01-04	62.372296	28.623592	44.512582	62.372296	62.372296	-25.685115	-25.6851
...	...	...	...	...	...	...	...	
318	2022-11-14	62.389808	42.809506	59.076121	62.384517	62.396045	-11.402532	-11.4025
319	2022-11-15	62.389864	41.878208	57.724536	62.384497	62.396176	-12.484569	-12.4845
320	2022-11-16	62.389920	45.437774	61.624614	62.384477	62.396307	-8.938570	-8.9385
321	2022-11-17	62.389976	42.618795	58.418187	62.384458	62.396406	-12.181175	-12.1811
322	2022-11-18	62.390031	41.367413	57.569264	62.384438	62.396503	-12.901366	-12.9013

323 rows × 25 columns

In [32]:
```
# Show plot

from prophet.plot import plot_plotly, plot_components_plotly, plot_cross_validation_met

plot_components_plotly(m, predictions)
```



In [33]:
```
# Show coeffients

from prophet.utilities import regressor_coefficients

regressor_coefficients(m)
```

Out[33]:

	regressor	regressor_mode	center	coef_lower	coef	coef_upper
0	max_temp	additive	61.758648	0.550366	0.550366	0.550366

In [34]:
```
# Define predictions for test
predictions.index = test.index
predictions["actual"] = test["y"]
```

In [35]:
```
# Evaluate model using mean squared error
def mse(predictions, actual_label="actual", pred_label="yhat"):
    se = ((predictions[actual_label] - predictions[pred_label]) ** 2)
    print(se.mean())

mse(predictions)
```

```
44.59952168961901
```

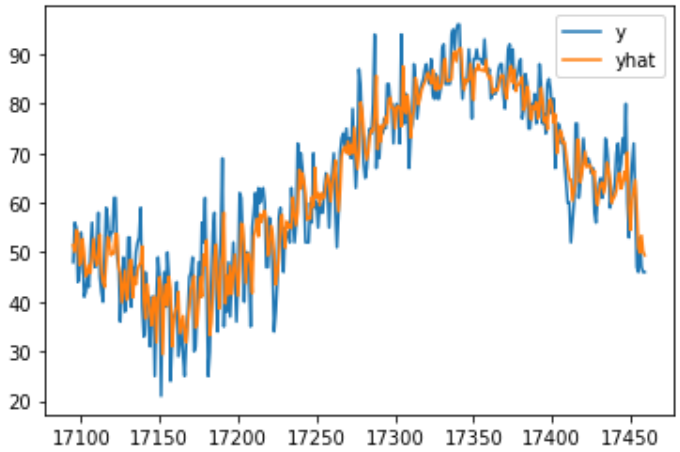
In [36]:
```
# Cross validate across data set
from prophet.diagnostics import cross_validation, performance_metrics

m = fit_prophet(core_weather)
cv = cross_validation(m, initial=f'{365 * 5} days', period='180 days', horizon = '180 d
```

```
15:00:41 - cmdstanpy - INFO - Chain [1] start processing
15:01:10 - cmdstanpy - INFO - Chain [1] done processing
```

In [37]:
```
mse(cv, actual_label="y")
```

```
40.12439483850038
```

In [38]:
```
cv[["y", "yhat"]][-365:].plot();
```



In [39]:
```
# Predict one day ahead with high accuracy
m = fit_prophet(core_weather)
m.predict(core_weather.iloc[-1:])
```

```
15:41:45 - cmdstanpy - INFO - Chain [1] start processing
15:42:19 - cmdstanpy - INFO - Chain [1] done processing
```

Out[39]:

	ds	trend	yhat_lower	yhat_upper	trend_lower	trend_upper	additive_terms	additive_terms_lower
0	2022-11-18	62.451298	41.763267	58.181184	62.451298	62.451298	-12.949946	-12.949946

1 rows × 25 columns

In [40]:
```
# Predict multiple days ahead with lower accuracy
m = Prophet()
m.fit(core_weather)
future = m.make_future_dataframe(periods=365)
forecast = m.predict(future)
```

```
15:42:28 - cmdstanpy - INFO - Chain [1] start processing
15:42:49 - cmdstanpy - INFO - Chain [1] done processing
```

In [41]:
```
# Show the forecast
from prophet.plot import plot_plotly

plot_plotly(m, forecast)
```