In [1]:

```
# Generic inputs for most ML tasks
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
# This is new
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import BaggingClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import GradientBoostingClassifier
from sklearn.linear_model import Ridge
from sklearn.linear_model import Lasso
from sklearn.ensemble import RandomForestRegressor

pd.options.display.float_format = '{:,.2f}'.format

# setup interactive notebook mode
from IPython.core.interactiveshell import InteractiveShell
InteractiveShell.ast_node_interactivity = "all"

from IPython.display import display, HTML
```

Fetching Flight data

In [2]:

```
# fetch data

mco_syr_sw_data = pd.read_csv('flight_data/mco_syr_sw_combined.csv')
mco_syr_jb_data = pd.read_csv('flight_data/mco_syr_jb_combined.csv')
jfk_syr_jb_data = pd.read_csv('flight_data/jfk_syr_jb_combined.csv')
jfk_syr_end_data = pd.read_csv('flight_data/jfk_syr_dl_combined.csv')
ord_syr_ua_data = pd.read_csv('flight_data/ord_syr_ua_combined.csv')
ord_syr_aa_data = pd.read_csv('flight_data/ord_syr_aa_combined.csv')
```

In [3]:

```
dfs = [ord_syr_aa_data,ord_syr_ua_data,jfk_syr_end_data,jfk_syr_jb_data,mco_syr_jb_data,mco_syr_sw_data]
main_data = pd.concat(dfs,axis = 0)
main_data.head()
len(main_data)
```

Out[3]:

	Unnamed: 0	Carrier_Code	Date	Flight_Number	Tail_Number	Destination_Airport	Scheduled departure time	Actual departure time	Scheduled elapsed time (Minutes)	Actual elapsed time (Minutes)	..
0	0	MQ	2020-01-04	3,580.00	N240NN	SYR	7:55	8:21	112.00	87.00	..
1	1	MQ	2020-01-11	3,946.00	N247NN	SYR	15:00	15:09	108.00	132.00	..
2	2	MQ	2020-01-18	3,946.00	N265NN	SYR	15:00	16:27	108.00	147.00	..
3	3	MQ	2020-01-25	3,946.00	N281NN	SYR	15:00	14:55	108.00	126.00	..
4	4	MQ	2020-02-01	3,946.00	N283NN	SYR	15:00	14:57	108.00	99.00	..

5 rows × 36 columns

Out[3]:

```
8661
```

In [4]:

```
main_data.isna().sum()
```

Out[4]:

```
Unnamed: 0                             0
Carrier_Code                           0
Date                                   0
Flight_Number                          0
Tail_Number                           74
Destination_Airport                    0
Scheduled departure time               0
Actual departure time                  0
Scheduled elapsed time (Minutes)       0
Actual elapsed time (Minutes)          0
Departure delay (Minutes)              0
Wheels-off time                        0
Taxi-Out time (Minutes)                0
dep_Delay_Carrier                      0
dep_Delay_Weather                      0
dep_Delay_National_Aviation_System     0
dep_Delay_Security                     0
dep_Delay_Late_Aircraft_Arrival        0
dep_hour                               0
dep_day                                0
dep_year                               0
dep_order                              0
Origin_Airport                         0
Scheduled Arrival Time                 0
Actual Arrival Time                    0
Arrival Delay (Minutes)                0
Wheels-on Time                         0
Taxi-In time (Minutes)                 0
arr_Delay_Carrier                      0
arr_Delay_Weather                      0
arr_Delay_National_Aviation_System     0
arr_Delay_Security                     0
arr_Delay_Late_Aircraft_Arrival        0
arr_hour                               0
arr_day                                0
arr_year                               0
dtype: int64
```

In [5]:

```
main_data.dtypes
```

Out[5]:

```
Unnamed: 0                               int64
Carrier_Code                            object
Date                                    object
Flight_Number                          float64
Tail_Number                             object
Destination_Airport                     object
Scheduled departure time                object
Actual departure time                   object
Scheduled elapsed time (Minutes)       float64
Actual elapsed time (Minutes)          float64
Departure delay (Minutes)              float64
Wheels-off time                         object
Taxi-Out time (Minutes)                float64
dep_Delay_Carrier                      float64
dep_Delay_Weather                      float64
dep_Delay_National_Aviation_System     float64
dep_Delay_Security                     float64
dep_Delay_Late_Aircraft_Arrival        float64
dep_hour                                 int64
dep_day                                  int64
dep_year                                 int64
dep_order                               object
Origin_Airport                          object
Scheduled Arrival Time                  object
Actual Arrival Time                     object
Arrival Delay (Minutes)                float64
Wheels-on Time                          object
Taxi-In time (Minutes)                 float64
arr_Delay_Carrier                      float64
arr_Delay_Weather                      float64
arr_Delay_National_Aviation_System     float64
arr_Delay_Security                     float64
arr_Delay_Late_Aircraft_Arrival        float64
arr_hour                                 int64
arr_day                                  int64
arr_year                                 int64
dtype: object
```

Preprocessing flight data

In [6]:

```
sub_data = main_data.drop(columns = ['Unnamed: 0','Destination_Airport','Actual departure time','Scheduled
                          'Wheels-off time','Taxi-Out time (Minutes)','dep_Delay_Carrier',
                          'dep_Delay_Weather','dep_Delay_National_Aviation_System','dep_Delay_Security','de
                          'dep_year','Actual Arrival Time','Wheels-on Time','Taxi-In time (Minutes)','arr_D
                          'arr_Delay_National_Aviation_System','arr_Delay_Security','arr_Delay_Late_Aircraf
```

In [7]:

```
sub_data.dtypes
```

Out[7]:

```
Carrier_Code                 object
Date                         object
Flight_Number               float64
Tail_Number                  object
Scheduled departure time     object
Departure delay (Minutes)   float64
dep_hour                      int64
dep_day                       int64
dep_order                    object
Origin_Airport               object
Scheduled Arrival Time       object
Arrival Delay (Minutes)     float64
arr_hour                      int64
arr_day                       int64
dtype: object
```

In [8]:

```
sub_data.head()
```

Out[8]:

	Carrier_Code	Date	Flight_Number	Tail_Number	Scheduled departure time	Departure delay (Minutes)	dep_hour	dep_day	dep_order	Origin_Airport	Schedul Arri Ti
0	MQ	2020-01-04	3,580.00	N240NN	7:55	26.00	7	5	latter	ORD	10
1	MQ	2020-01-11	3,946.00	N247NN	15:00	9.00	15	5	latter	ORD	17
2	MQ	2020-01-18	3,946.00	N265NN	15:00	87.00	15	5	latter	ORD	17
3	MQ	2020-01-25	3,946.00	N281NN	15:00	-5.00	15	5	latter	ORD	17
4	MQ	2020-02-01	3,946.00	N283NN	15:00	-3.00	15	5	latter	ORD	17

In [9]:

```
sub_data['dep_min'] = sub_data['Scheduled departure time'].str.split(":").str[1].astype('int64')
sub_data['Date'] = pd.to_datetime( sub_data['Date'],format ="%Y-%m-%d")
sub_data['Date'] = sub_data['Date'].dt.strftime('%m/%d/%Y')
sub_data['dep_hours'] = sub_data['dep_hour'].astype('object')
sub_data['dep_min'] = sub_data['dep_min'].astype('object')
sub_data['arr_min'] = main_data['Scheduled Arrival Time'].str.split(":").str[1].astype('int64')
sub_data['arr_hours'] = sub_data['arr_hour'].astype('object')
sub_data['arr_min'] = sub_data['arr_min'].astype('object')
sub_data['Flight_Number'] = main_data['Flight_Number'].astype('object')
sub_data['dep_hour'] = main_data['dep_hour'].astype('object')
sub_data['dep_day'] = main_data['dep_day'].astype('object')
sub_data['arr_hour'] = main_data['arr_hour'].astype('object')
sub_data['arr_day'] = main_data['arr_day'].astype('object')
conditions = [
    (sub_data['Arrival Delay (Minutes)'] > 5),
    (sub_data['Arrival Delay (Minutes)'] >=-5) & (sub_data['Arrival Delay (Minutes)'] <= 5),
    (sub_data['Arrival Delay (Minutes)'] < -5)
]
conditions2 = [
    (sub_data['Departure delay (Minutes)'] > 5),
    (sub_data['Departure delay (Minutes)'] >=-5) & (sub_data['Departure delay (Minutes)'] <= 5),
    (sub_data['Departure delay (Minutes)'] < -5)
]
choices = [2,1,0]
sub_data['arr_status'] = np.select(conditions, choices)
sub_data['dep_status'] = np.select(conditions2, choices)
sub_data.dtypes
sub_data.head()
len(sub_data)
```

Out[9]:

```
Carrier_Code                  object
Date                          object
Flight_Number                 object
Tail_Number                   object
Scheduled departure time      object
Departure delay (Minutes)    float64
dep_hour                      object
dep_day                       object
dep_order                     object
Origin_Airport                object
Scheduled Arrival Time        object
Arrival Delay (Minutes)      float64
arr_hour                      object
arr_day                       object
dep_min                       object
dep_hours                     object
arr_min                       object
arr_hours                     object
arr_status                     int32
dep_status                     int32
dtype: object
```

Out[9]:

	Carrier_Code	Date	Flight_Number	Tail_Number	Scheduled departure time	Departure delay (Minutes)	dep_hour	dep_day	dep_order	Origin_Airport	Sc
0	MQ	01/04/2020	3,580.00	N240NN	7:55	26.00	7	5	latter	ORD	
1	MQ	01/11/2020	3,946.00	N247NN	15:00	9.00	15	5	latter	ORD	
2	MQ	01/18/2020	3,946.00	N265NN	15:00	87.00	15	5	latter	ORD	
3	MQ	01/25/2020	3,946.00	N281NN	15:00	-5.00	15	5	latter	ORD	
4	MQ	02/01/2020	3,946.00	N283NN	15:00	-3.00	15	5	latter	ORD	

Out[9]: 8661

In [10]:

```
#sub_data.to_csv('sub_data.csv', index=False)
```

Filtering flights with arrival delay less than 120 mins

```
In [11]:  len(sub_data)
          sub_data= sub_data[sub_data['Arrival Delay (Minutes)'] < 120]
          len(sub_data)

Out[11]:  8661

Out[11]:  8405
```

Fetching Weather data

In [12]:

```
# Read and process weather data files for each airport

jfk_weather_data = pd.read_csv('weather_data/JFK_weather_data_hourly_processed.csv')
syr_weather_data = pd.read_csv('weather_data/SYR_weather_data_hourly_processed.csv')
ord_weather_data = pd.read_csv('weather_data/ORD_weather_data_hourly_processed.csv')
mco_weather_data = pd.read_csv('weather_data/MCO_weather_data_hourly_processed.csv')

# Combine weather data for all airports
weather_dfs = [jfk_weather_data, ord_weather_data, mco_weather_data]
weather_data = pd.concat(weather_dfs, axis=0)
weather_data['dep_hours'] = weather_data['dep_hours'].astype('object')
syr_weather_data['arr_hours'] = syr_weather_data['arr_hours'].astype('object')
weather_data.head()
syr_weather_data.head()
weather_data.dtypes
syr_weather_data.dtypes
```

Out[12]:

	dep_azimuth	dep_clouds	dep_dewpt	dep_elev_angle	dep_h_angle	dep_precip	dep_pres	dep_revision_status	dep_rh	dep_sn
0	261.20	100	3.80	-26.20	NaN	0.00	1002	final	88	0
1	270.50	100	3.90	-37.50	NaN	0.25	1003	final	85	0
2	281.40	100	3.70	-48.80	NaN	0.00	1003	final	82	0
3	296.30	100	1.60	-59.60	NaN	0.00	1002	final	73	0
4	320.80	100	0.70	-68.60	NaN	0.00	1003	final	69	0

Out[12]:

	arr_azimuth	arr_clouds	arr_dewpt	arr_elev_angle	arr_h_angle	arr_precip	arr_pres	arr_revision_status	arr_rh	arr_snow	arr_t
0	260.90	100	-2.30	-24.90	NaN	0.00	987	final	78	0.00	
1	270.70	100	-3.00	-35.80	NaN	0.00	987	final	77	0.00	
2	282.10	100	-4.00	-46.60	NaN	0.00	986	final	71	0.00	
3	297.00	100	-4.40	-56.90	NaN	0.00	987	final	69	0.00	
4	319.80	100	-4.40	-65.60	NaN	0.00	986	final	69	0.00	

Out[12]:

```
dep_azimuth                 float64
dep_clouds                    int64
dep_dewpt                   float64
dep_elev_angle              float64
dep_h_angle                 float64
dep_precip                  float64
dep_pres                      int64
dep_revision_status          object
dep_rh                        int64
dep_snow                    float64
dep_temp                    float64
dep_vis                       int64
dep_weather.description      object
dep_weather.code              int64
dep_wind_dir                  int64
dep_wind_gust_spd           float64
dep_wind_spd                float64
Date                         object
dep_hours                    object
Origin_Airport               object
dtype: object
```

```
Out[12]: arr_azimuth                float64
         arr_clouds                   int64
         arr_dewpt                  float64
         arr_elev_angle             float64
         arr_h_angle                float64
         arr_precip                 float64
         arr_pres                     int64
         arr_revision_status         object
         arr_rh                       int64
         arr_snow                   float64
         arr_temp                   float64
         arr_vis                      int64
         arr_weather.description     object
         arr_weather.code             int64
         arr_wind_dir                 int64
         arr_wind_gust_spd          float64
         arr_wind_spd               float64
         Date                        object
         arr_hours                   object
         dtype: object
```

Merging flight and weather data

In [13]:

```
sub_data = pd.merge(sub_data, weather_data, how='left', on=['Origin_Airport', 'Date', 'dep_hours'])

sub_data.head()
```

Out[13]:

	Carrier_Code	Date	Flight_Number	Tail_Number	Scheduled departure time	Departure delay (Minutes)	dep_hour	dep_day	dep_order	Origin_Airport	...
0	MQ	01/04/2020	3,580.00	N240NN	7:55	26.00	7	5	latter	ORD	...
1	MQ	01/11/2020	3,946.00	N247NN	15:00	9.00	15	5	latter	ORD	...
2	MQ	01/25/2020	3,946.00	N281NN	15:00	-5.00	15	5	latter	ORD	...
3	MQ	02/01/2020	3,946.00	N283NN	15:00	-3.00	15	5	latter	ORD	...
4	MQ	02/08/2020	3,946.00	N274NN	15:00	-4.00	15	5	latter	ORD	...

5 rows × 37 columns

In [14]:

```
# Define merging logic based on airport code
sub_data = pd.merge(sub_data, syr_weather_data, how='left', on=['Date', 'arr_hours'])
sub_data.head()
```

Out[14]:

	Carrier_Code	Date	Flight_Number	Tail_Number	Scheduled departure time	Departure delay (Minutes)	dep_hour	dep_day	dep_order	Origin_Airport	...
0	MQ	01/04/2020	3,580.00	N240NN	7:55	26.00	7	5	latter	ORD	...
1	MQ	01/11/2020	3,946.00	N247NN	15:00	9.00	15	5	latter	ORD	...
2	MQ	01/25/2020	3,946.00	N281NN	15:00	-5.00	15	5	latter	ORD	...
3	MQ	02/01/2020	3,946.00	N283NN	15:00	-3.00	15	5	latter	ORD	...
4	MQ	02/08/2020	3,946.00	N274NN	15:00	-4.00	15	5	latter	ORD	...

5 rows × 54 columns

In [15]:

```
sub_data.isna().sum()
```

Out[15]:

```
Carrier_Code                     0
Date                             0
Flight_Number                    0
Tail_Number                     74
Scheduled departure time         0
Departure delay (Minutes)        0
dep_hour                         0
dep_day                          0
dep_order                        0
Origin_Airport                   0
Scheduled Arrival Time           0
Arrival Delay (Minutes)          0
arr_hour                         0
arr_day                          0
dep_min                          0
dep_hours                        0
arr_min                          0
arr_hours                        0
arr_status                       0
dep_status                       0
dep_azimuth                      0
dep_clouds                       0
dep_dewpt                        0
dep_elev_angle                   0
dep_h_angle                   8405
dep_precip                       0
dep_pres                         0
dep_revision_status              0
dep_rh                           0
dep_snow                         0
dep_temp                         0
dep_vis                          0
dep_weather.description          0
dep_weather.code                 0
dep_wind_dir                     0
dep_wind_gust_spd                0
dep_wind_spd                     0
arr_azimuth                      0
arr_clouds                       0
arr_dewpt                        0
arr_elev_angle                   0
arr_h_angle                   8405
arr_precip                       0
```

```
arr_pres                    0
arr_revision_status         0
arr_rh                      0
arr_snow                    0
arr_temp                    0
arr_vis                     0
arr_weather.description     0
arr_weather.code            0
arr_wind_dir                0
arr_wind_gust_spd           0
arr_wind_spd                0
dtype: int64
```

In [16]:

```
sub_data.columns
```

Out[16]:

```
Index(['Carrier_Code', 'Date', 'Flight_Number', 'Tail_Number',
       'Scheduled departure time', 'Departure delay (Minutes)', 'dep_hour',
       'dep_day', 'dep_order', 'Origin_Airport', 'Scheduled Arrival Time',
       'Arrival Delay (Minutes)', 'arr_hour', 'arr_day', 'dep_min',
       'dep_hours', 'arr_min', 'arr_hours', 'arr_status', 'dep_status',
       'dep_azimuth', 'dep_clouds', 'dep_dewpt', 'dep_elev_angle',
       'dep_h_angle', 'dep_precip', 'dep_pres', 'dep_revision_status',
       'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis', 'dep_weather.description',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_azimuth', 'arr_clouds', 'arr_dewpt', 'arr_elev_angle',
       'arr_h_angle', 'arr_precip', 'arr_pres', 'arr_revision_status',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.description',
       'arr_weather.code', 'arr_wind_dir', 'arr_wind_gust_spd',
       'arr_wind_spd'],
      dtype='object')
```

In [17]:

```
sub_data.drop(columns= ['Carrier_Code','Date','Flight_Number','Tail_Number','arr_azimuth',
                       'Scheduled departure time','Scheduled Arrival Time','dep_order',
                        'arr_hours', 'dep_hours','arr_weather.description', 'dep_weather.description',
                        'Arrival Delay (Minutes)','Departure delay (Minutes)','arr_elev_angle','arr_h_angl
                        'arr_revision_status','dep_elev_angle','dep_h_angle','dep_revision_status','dep_az
              inplace = True)
```

In [18]:

```
sub_data.dtypes
sub_data.columns
sub_data.head()
sub_data.isna().sum()
```

Out[18]:

```
dep_hour              object
dep_day               object
Origin_Airport        object
arr_hour              object
arr_day               object
dep_min               object
arr_min               object
arr_status             int32
dep_status             int32
dep_clouds             int64
dep_dewpt            float64
dep_precip           float64
dep_pres               int64
dep_rh                 int64
dep_snow             float64
dep_temp             float64
dep_vis                int64
dep_weather.code       int64
dep_wind_dir           int64
dep_wind_gust_spd    float64
dep_wind_spd         float64
arr_clouds             int64
arr_dewpt            float64
arr_precip           float64
arr_pres               int64
arr_rh                 int64
arr_snow             float64
arr_temp             float64
arr_vis                int64
arr_weather.code       int64
arr_wind_dir           int64
arr_wind_gust_spd    float64
arr_wind_spd         float64
dtype: object
```

```
Out[18]: Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
               'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
               'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
               'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
               'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
               'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
               'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
              dtype='object')
```

```
Out[18]:
```

	dep_hour	dep_day	Origin_Airport	arr_hour	arr_day	dep_min	arr_min	arr_status	dep_status	dep_clouds	...	arr_precip	arr_
0	7	5	ORD	10	5	55	47	1	2	100	...	1.50	
1	15	5	ORD	17	5	0	48	2	2	100	...	1.50	
2	15	5	ORD	17	5	0	48	2	1	100	...	1.50	
3	15	5	ORD	17	5	0	48	0	1	100	...	0.00	
4	15	5	ORD	17	5	0	48	0	1	100	...	0.00	

5 rows × 33 columns

Out[18]:

```
dep_hour             0
dep_day              0
Origin_Airport       0
arr_hour             0
arr_day              0
dep_min              0
arr_min              0
arr_status           0
dep_status           0
dep_clouds           0
dep_dewpt            0
dep_precip           0
dep_pres             0
dep_rh               0
dep_snow             0
dep_temp             0
dep_vis              0
dep_weather.code     0
dep_wind_dir         0
dep_wind_gust_spd    0
dep_wind_spd         0
arr_clouds           0
arr_dewpt            0
arr_precip           0
arr_pres             0
arr_rh               0
arr_snow             0
arr_temp             0
arr_vis              0
arr_weather.code     0
arr_wind_dir         0
arr_wind_gust_spd    0
arr_wind_spd         0
dtype: int64
```

In [19]:

```
#sub_data.to_csv('merged_data.csv', index=False)
```

Analysing combined data

In [20]:

```
# define function to import viz libraries
import plotly
plotly.offline.init_notebook_mode(connected=True)
from plotly.graph_objs import *
from plotly import tools
import plotly.graph_objects as go
import seaborn as sns
```

In [21]:

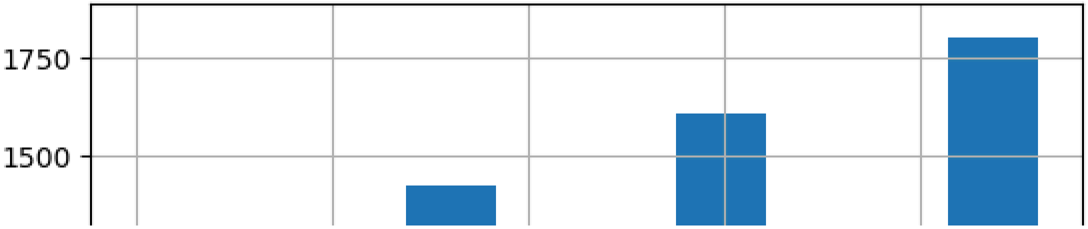
```
cols = sub_data.columns
print(cols)
for col in cols:
    sub_data[col].hist()
    print(col)
    plt.show()
```

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

Out[21]:

```
<Axes: >
```

```
dep_hour
```



In [22]:

```
import plotly.express as px
```

In [23]:

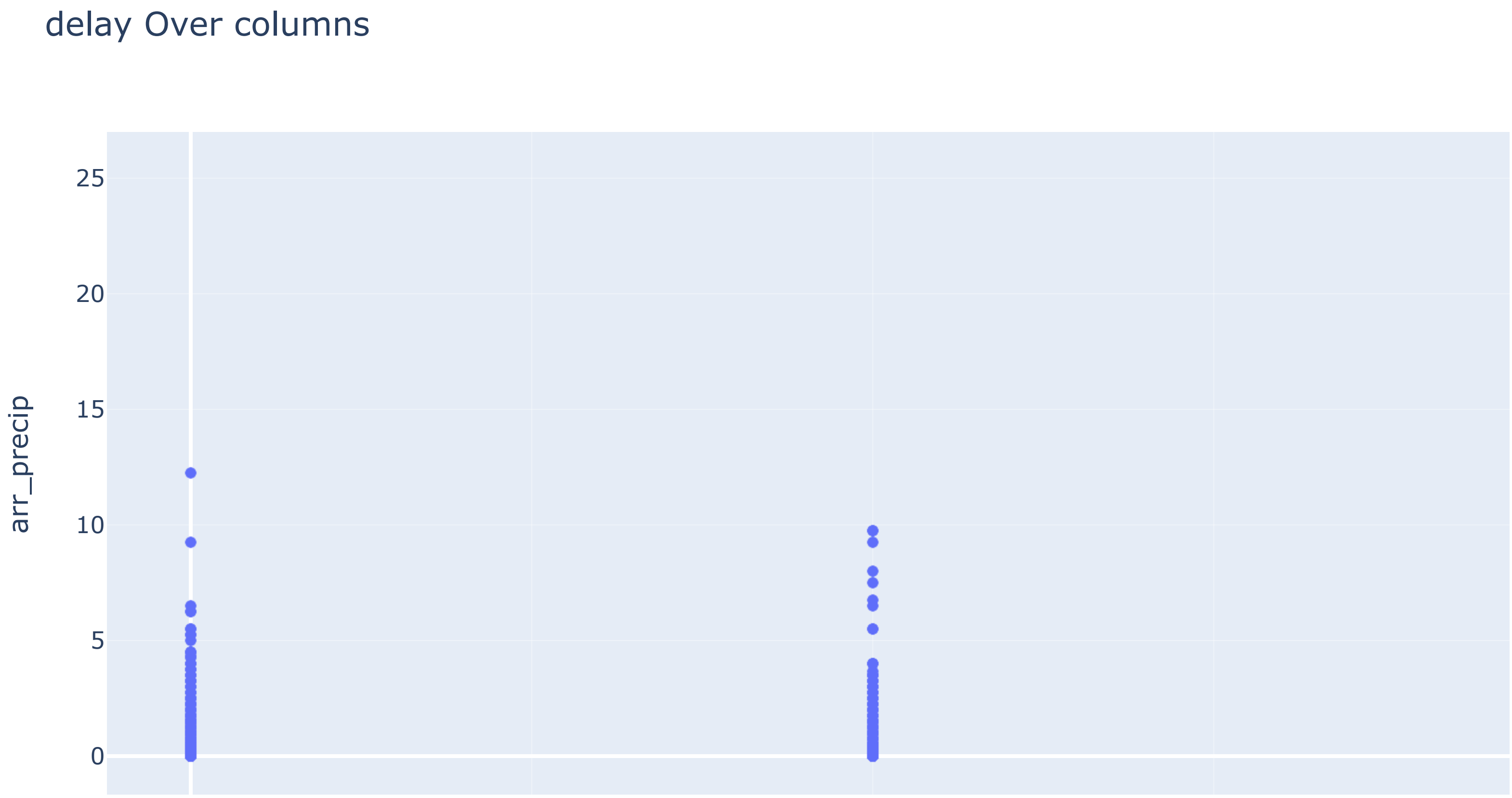
```
sub_data.columns
```

Out[23]:

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [24]:

```
#for co in sub_data.columns:
fig = px.scatter(sub_data, y='arr_precip', x='arr_status', title='delay Over columns')
fig.show()
```



Squaring precip columns

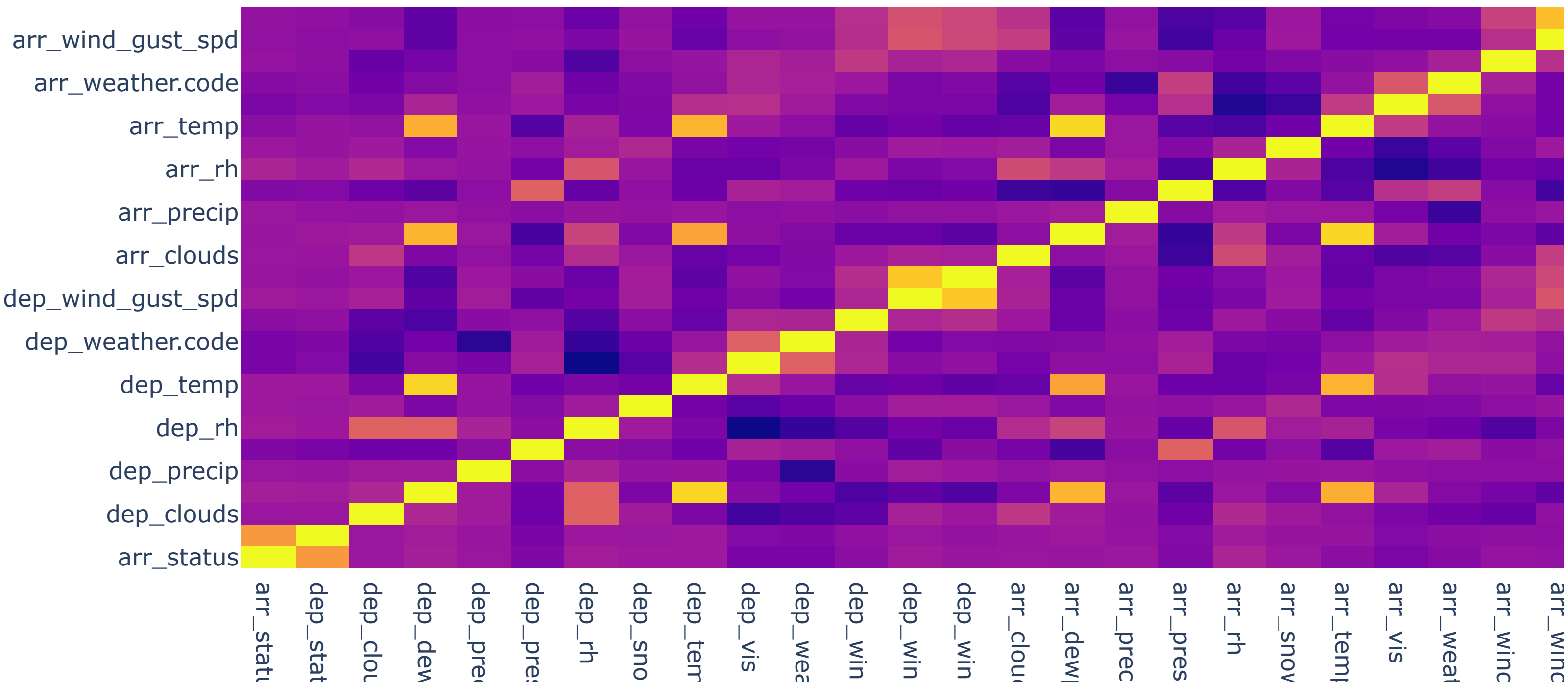
In [25]:

```
sub_data['dep_precip'] = sub_data['dep_precip']**2
sub_data['arr_precip'] = sub_data['arr_precip']**2
```

In [26]:

```
# correl = subset_data.corr()
correl = sub_data.corr(numeric_only=True)

trace = go.Heatmap(z=correl.values,
                   x=correl.index.values,
                   y=correl.columns.values)
data=[trace]
plotly.offline.iplot(data, filename='basic-heatmap')
```



In [27]:

```
su_data = sub_data
su_data['dep_hour'] = pd.Categorical(su_data['dep_hour'], categories=[i for i in range(24)])
su_data['dep_day'] = pd.Categorical(su_data['dep_day'], categories=[i for i in range(7)])
su_data['dep_min'] = pd.Categorical(su_data['dep_min'], categories=[i for i in range(60)])
su_data['arr_hour'] = pd.Categorical(su_data['arr_hour'], categories=[i for i in range(24)])
su_data['arr_day'] = pd.Categorical(su_data['arr_day'], categories=[i for i in range(7)])
su_data['arr_min'] = pd.Categorical(su_data['arr_min'], categories=[i for i in range(60)])
su_data['Origin_Airport'] = pd.Categorical(su_data['Origin_Airport'], categories=['ORD', 'JFK', 'MCO'])
su_data['arr_weather.code'] = pd.Categorical(su_data['arr_weather.code'], categories=[200,201,202,230,231,
su_data['dep_weather.code'] = pd.Categorical(su_data['dep_weather.code'], categories=[200,201,202,230,231,

su_data.columns
```

Out[27]:

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [28]:

```
su_data.dtypes
```

Out[28]:

```
dep_hour               category
dep_day                category
Origin_Airport         category
arr_hour               category
arr_day                category
dep_min                category
arr_min                category
arr_status                int32
dep_status                int32
dep_clouds                int64
dep_dewpt               float64
dep_precip              float64
dep_pres                  int64
dep_rh                    int64
dep_snow                float64
dep_temp                float64
dep_vis                   int64
dep_weather.code       category
dep_wind_dir              int64
dep_wind_gust_spd       float64
dep_wind_spd            float64
arr_clouds                int64
arr_dewpt               float64
arr_precip              float64
arr_pres                  int64
arr_rh                    int64
arr_snow                float64
arr_temp                float64
arr_vis                   int64
arr_weather.code       category
arr_wind_dir              int64
arr_wind_gust_spd       float64
arr_wind_spd            float64
dtype: object
```

In [29]:

```
# data to predict departure status
dep_data = su_data.drop(columns = ['arr_status'])
```

In [30]:

```
# data to predict arrival status
arr_data = su_data.drop(columns = ['dep_status'])
```

predicting arrival status without departure status

In [31]:

```
arr_data.columns
```

Out[31]:

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_clouds', 'dep_dewpt',
       'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [32]:

```
arr_data_d = pd.get_dummies(arr_data, drop_first = True)
arr_data_d.head()
```

Out[32]:

	arr_status	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	...	arr_weathe
0	1	100	-2.80	0.00	989	88	0.00	-1.10	11	320	...	
1	2	100	-1.20	0.25	985	96	8.50	-0.60	2	20	...	
2	2	100	-0.30	0.25	985	92	4.00	0.80	6	255	...	
3	0	100	-2.00	0.00	984	73	0.00	2.40	16	255	...	
4	0	100	-6.30	0.00	995	56	0.00	1.60	16	235	...	

5 rows × 271 columns

In [33]:

```
X_train, X_test, y_train, y_test = train_test_split(arr_data_d.drop(columns = ['arr_status']), arr_data_d[

X_train
X_test
y_train
y_test
```

Out[33]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
4212	87	11.10	0.00	1027	76	0.00	15.30	16	155	10.00	...
3356	25	6.60	0.00	1024	58	0.00	14.80	16	330	6.00	...
7366	25	16.90	0.00	1013	40	0.00	32.20	16	180	8.80	...
151	95	23.50	16.00	985	62	0.00	31.70	16	185	19.50	...
4874	100	17.70	0.00	1008	90	0.00	19.40	16	140	10.00	...
...	...	...	...	...	...	...	...	...	...	...	...
3785	43	-10.70	0.00	1029	42	0.00	0.70	16	280	8.50	...
7727	25	-8.10	0.00	1015	26	0.00	10.60	16	310	12.40	...
301	40	20.70	0.00	985	75	0.00	25.40	16	175	10.40	...
2076	87	4.00	0.00	993	23	0.00	26.90	16	100	6.00	...
7121	87	-2.20	0.00	1010	54	0.00	6.40	16	320	15.80	...

6724 rows × 270 columns

Out[33]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
5077	100	8.30	0.00	1006	77	0.00	12.20	16	350	12.20	...
4929	100	12.10	0.00	1021	93	0.00	13.30	5	35	8.40	...
6164	59	-13.40	0.00	1025	36	0.00	-0.10	16	330	5.55	...
316	87	6.00	0.00	990	67	0.00	12.00	16	325	11.40	...
8344	50	16.40	0.00	1016	50	0.00	27.80	16	60	4.40	...
...	...	...	...	...	...	...	...	...	...	...	...
2045	0	-3.60	0.00	990	25	0.00	16.40	16	60	7.20	...
6260	78	-5.40	0.00	1014	44	0.00	5.90	16	310	12.00	...
6959	78	10.60	0.00	1006	69	0.00	16.30	16	235	8.00	...
5651	78	20.50	0.00	1013	72	0.00	26.00	16	250	4.00	...
6051	100	8.30	0.00	1009	100	0.00	8.30	2	175	9.20	...

1681 rows × 270 columns

Out[33]:

```
4212    1
3356    0
7366    1
151     0
4874    0
       ..
3785    0
7727    0
301     2
2076    2
7121    0
Name: arr_status, Length: 6724, dtype: int32
```

Out[33]:
```
5077    1
4929    0
6164    0
316     2
8344    2
       ..
2045    0
6260    2
6959    0
5651    2
6051    0
Name: arr_status, Length: 1681, dtype: int32
```

In [34]:

```python
from sklearn.preprocessing import StandardScaler
sc_d = StandardScaler()
X_train = pd.DataFrame(sc_d.fit_transform(X_train), columns = X_train.columns, index = X_train.index)
X_test = pd.DataFrame(sc_d.transform(X_test), columns = X_test.columns, index = X_test.index)
X_train
X_test
y_train
y_test
```

Out[34]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
4212	0.63	0.33	-0.08	1.44	0.69	-0.06	-0.02	0.31	-0.40	0.72	...
3356	-1.35	-0.12	-0.08	1.21	-0.26	-0.06	-0.07	0.31	1.39	-0.49	...
7366	-1.35	0.91	-0.08	0.40	-1.21	-0.06	1.72	0.31	-0.15	0.35	...
151	0.89	1.57	1.51	-1.69	-0.05	-0.06	1.67	0.31	-0.09	3.59	...
4874	1.05	0.99	-0.08	0.02	1.43	-0.06	0.40	0.31	-0.56	0.72	...
...	...	...	...	...	...	...	...	...	...	...	...
3785	-0.78	-1.85	-0.08	1.59	-1.11	-0.06	-1.53	0.31	0.88	0.26	...
7727	-1.35	-1.59	-0.08	0.55	-1.95	-0.06	-0.50	0.31	1.18	1.44	...
301	-0.87	1.29	-0.08	-1.69	0.64	-0.06	1.02	0.31	-0.20	0.84	...
2076	0.63	-0.38	-0.08	-1.09	-2.11	-0.06	1.18	0.31	-0.97	-0.49	...
7121	0.63	-1.00	-0.08	0.17	-0.47	-0.06	-0.94	0.31	1.29	2.47	...

6724 rows × 270 columns

Out[34]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
5077	1.05	0.05	-0.08	-0.12	0.74	-0.06	-0.34	0.31	1.59	1.38	...
4929	1.05	0.43	-0.08	0.99	1.59	-0.06	-0.23	-3.57	-1.63	0.23	...
6164	-0.27	-2.12	-0.08	1.29	-1.43	-0.06	-1.61	0.31	1.39	-0.63	...
316	0.63	-0.18	-0.08	-1.31	0.21	-0.06	-0.36	0.31	1.34	1.14	...
8344	-0.55	0.86	-0.08	0.62	-0.69	-0.06	1.27	0.31	-1.37	-0.98	...
...	...	...	...	...	...	...	...	...	...	...	...
2045	-2.16	-1.14	-0.08	-1.31	-2.01	-0.06	0.09	0.31	-1.37	-0.13	...
6260	0.34	-1.32	-0.08	0.47	-1.00	-0.06	-0.99	0.31	1.18	1.32	...
6959	0.34	0.28	-0.08	-0.12	0.32	-0.06	0.08	0.31	0.42	0.11	...
5651	0.34	1.27	-0.08	0.40	0.48	-0.06	1.08	0.31	0.57	-1.10	...
6051	1.05	0.05	-0.08	0.10	1.96	-0.06	-0.74	-4.62	-0.20	0.47	...

1681 rows × 270 columns

Out[34]:

```
4212    1
3356    0
7366    1
151     0
4874    0
       ..
3785    0
7727    0
301     2
2076    2
7121    0
Name: arr_status, Length: 6724, dtype: int32
```

Out[34]:

```
5077    1
4929    0
6164    0
316     2
8344    2
       ..
2045    0
6260    2
6959    0
5651    2
6051    0
Name: arr_status, Length: 1681, dtype: int32
```

In [35]:

```
arr_model = LogisticRegression(fit_intercept = True, solver='lbfgs', multi_class = 'ovr', penalty = None,

arr_model.fit(X_train, y_train)

arr_model.score(X_train, y_train)

arr_model.coef_

arr_model.intercept_
```

Out[35]:

```
▾                    LogisticRegression
LogisticRegression(max_iter=1000, multi_class='ovr', penalty=None)
```

Out[35]:

```
0.5886377156454491
```

Out[35]:

```
array([[ 2.73364144e-02,  5.75927379e-01, -5.95958626e-01,
         6.34190607e-02, -3.12390194e-01, -2.68753458e-01,
        -5.44369681e-01,  1.44259015e-01, -9.87266761e-03,
        -2.10203488e-01,  8.43471105e-02,  2.24841203e-01,
        -4.46048944e-01, -5.63119720e-01, -2.49237530e-02,
         9.01785598e-02,  5.23536159e-02,  3.62944330e-01,
         1.64380959e-01, -9.38948470e-02,  1.47854963e-02,
        -4.24998064e-02,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
         2.62090159e+00,  3.48824367e+00,  6.18613394e+00,
         6.29928641e+00,  3.02255036e+00,  3.09512588e+00,
         2.25764275e+00,  2.51991554e+00,  8.95146400e-01,
         2.12000790e-01, -6.20813184e-01, -6.13614782e-01,
```

In [36]:

```
arr_model.score(X_test, y_test)
```

Out[36]:

```
0.5443188578227246
```

In [37]:

```
arr_rf = RandomForestClassifier(random_state=50, min_samples_leaf = 4, max_features = "sqrt", n_estimators

arr_rf = arr_rf.fit(X_train, y_train)
arr_rf.score(X_train, y_train)

# rf.feature_importances_
feat_imp = pd.Series(arr_rf.feature_importances_, X_train.columns.values).sort_values(ascending=False)
feat_imp_table = pd.DataFrame(feat_imp)
feat_imp_table.head()

arr_rf_output = pd.DataFrame(arr_rf.predict(X_test), index = X_test.index, columns = ['pred_Y'])

arr_rf_output.head()
arr_rf_output = arr_rf_output.merge(y_test, left_index = True, right_index = True)
arr_rf_output.head()
print('Fraction of correct classification ')
arr_rf.score(X_test, y_test)
```

Out[37]:

```
0.7940214158239144
```

Out[37]:

	0
dep_dewpt	0.05
dep_temp	0.05
arr_dewpt	0.05
arr_rh	0.05
dep_rh	0.04

Out[37]:

	pred_Y
5077	0
4929	0
6164	0
316	0
8344	0

Out[37]:

	pred_Y	arr_status
5077	0	1
4929	0	0
6164	0	0
316	0	2
8344	0	2

```
Fraction of correct classification
```

Out[37]:
```
0.5455086258179654
```

In [38]:
```
arr_gb = GradientBoostingClassifier(random_state=50, min_samples_split = 8, min_samples_leaf = 4, n_estima

arr_gb = arr_gb.fit(X_train, y_train)
arr_gb.score(X_train, y_train)
```

Out[38]:
```
0.7125223081499108
```

In [39]:
```
arr_gb.score(X_test,y_test)
```

Out[39]:
```
0.5383700178465199
```

Training to predict departure status

In [40]:
```
dep_data.columns
```

Out[40]:
```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'dep_status', 'dep_clouds', 'dep_dewpt',
       'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [41]:

```
dep_data = pd.get_dummies(dep_data, drop_first = True)
dep_data.head()
```

Out[41]:

```
   dep_status  dep_clouds  dep_dewpt  dep_precip  dep_pres  dep_rh  dep_snow  dep_temp  dep_vis  dep_wind_dir  ...  arr_weathe
0           2         100      -2.80        0.00       989      88      0.00     -1.10       11           320  ...
1           2         100      -1.20        0.25       985      96      8.50     -0.60        2            20  ...
2           1         100      -0.30        0.25       985      92      4.00      0.80        6           255  ...
3           1         100      -2.00        0.00       984      73      0.00      2.40       16           255  ...
4           1         100      -6.30        0.00       995      56      0.00      1.60       16           235  ...

5 rows × 271 columns
```

In [42]:

```
X_train, X_test, y_train, y_test = train_test_split(dep_data.drop(columns = ['dep_status']), dep_data['dep

X_train
X_test
y_train
y_test
```

Out[42]:

```
      dep_clouds  dep_dewpt  dep_precip  dep_pres  dep_rh  dep_snow  dep_temp  dep_vis  dep_wind_dir  dep_wind_gust_spd  ...
5135          25      -2.90        0.00      1009      45      0.00      8.30       16           290              15.00  ...
1831          78       1.10        0.00       987      70      0.00      6.10       16           230               3.60  ...
7746          50       4.70        0.00      1014      32      0.00     22.20       16            30               4.80  ...
5034          43      -0.80        0.00      1025      44      0.00     11.00       16           320               6.80  ...
1763           0       1.10        0.00       994      35      0.00     16.60       16           285               4.40  ...
 ...         ...        ...         ...       ...     ...       ...       ...      ...           ...                ...  ...
6739          25      11.10        0.00      1020      55      0.00     20.40       16           290               2.97  ...
1508         100     -24.50        0.00       985      61      0.00    -18.90        4           270              18.80  ...
7410          87      20.80        0.25      1010      56      0.00     30.60       16           310               8.80  ...
5188          25       3.30        0.00      1022      82      0.00      6.10       16           200               4.80  ...
5266         100       6.60        0.00      1020      92      0.00      7.80       16            70              12.50  ...

6724 rows × 270 columns
```

Out[42]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
8306	87	20.90	0.00	1010	62	0.00	28.90	16	275	5.20	...
159	25	13.70	0.00	992	61	0.00	21.50	16	345	7.60	...
2785	87	-11.60	0.00	1028	35	0.00	2.20	16	310	6.80	...
7325	25	2.50	0.00	1023	36	0.00	17.80	16	50	11.30	...
63	43	11.90	0.00	989	72	0.00	17.00	16	245	4.00	...
...	...	...	...	...	...	...	...	...	...	...	...
5573	100	10.20	2.25	1018	100	0.00	10.20	10	120	13.50	...
4818	25	15.10	0.00	1021	90	0.00	16.70	16	135	2.60	...
8175	100	15.90	0.00	1017	50	0.00	27.20	16	360	4.40	...
7587	50	13.00	0.00	1000	39	0.00	28.30	16	240	11.30	...
2325	43	13.90	0.00	992	51	0.00	24.70	16	210	3.20	...

1681 rows × 270 columns

Out[42]:

```
5135    2
1831    0
7746    2
5034    1
1763    1
       ..
6739    2
1508    1
7410    2
5188    0
5266    2
Name: dep_status, Length: 6724, dtype: int32
```

```
Out[42]: 8306    1
         159     0
         2785    1
         7325    2
         63      1
                ..
         5573    1
         4818    2
         8175    0
         7587    1
         2325    0
         Name: dep_status, Length: 1681, dtype: int32
```

In [43]:

```python
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
X_train = pd.DataFrame(sc.fit_transform(X_train), columns = X_train.columns, index = X_train.index)
X_test = pd.DataFrame(sc.transform(X_test), columns = X_test.columns, index = X_test.index)
X_train
X_test
y_train
y_test
```

Out[43]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
5135	-1.34	-1.08	-0.08	0.09	-0.95	-0.06	-0.75	0.31	0.98	2.25	...
1831	0.34	-0.68	-0.08	-1.54	0.37	-0.06	-0.98	0.31	0.36	-1.22	...
7746	-0.55	-0.32	-0.08	0.46	-1.64	-0.06	0.69	0.31	-1.68	-0.86	...
5034	-0.77	-0.87	-0.08	1.28	-1.00	-0.06	-0.47	0.31	1.29	-0.25	...
1763	-2.14	-0.68	-0.08	-1.02	-1.48	-0.06	0.11	0.31	0.93	-0.98	...
...	...	...	...	...	...	...	...	...	...	...	...
6739	-1.34	0.33	-0.08	0.91	-0.42	-0.06	0.50	0.31	0.98	-1.41	...
1508	1.05	-3.24	-0.08	-1.69	-0.10	-0.06	-3.55	-3.86	0.77	3.41	...
7410	0.63	1.30	-0.04	0.17	-0.37	-0.06	1.55	0.31	1.18	0.36	...
5188	-1.34	-0.46	-0.08	1.06	1.01	-0.06	-0.98	0.31	0.06	-0.86	...
5266	1.05	-0.13	-0.08	0.91	1.54	-0.06	-0.80	0.31	-1.27	1.49	...

6724 rows × 270 columns

Out[43]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
8306	0.63	1.31	-0.08	0.17	-0.05	-0.06	1.38	0.31	0.82	-0.73	...
159	-1.34	0.59	-0.08	-1.17	-0.10	-0.06	0.61	0.31	1.54	-0.00	...
2785	0.63	-1.95	-0.08	1.50	-1.48	-0.06	-1.38	0.31	1.18	-0.25	...
7325	-1.34	-0.54	-0.08	1.13	-1.43	-0.06	0.23	0.31	-1.48	1.12	...
63	-0.77	0.41	-0.08	-1.40	0.48	-0.06	0.15	0.31	0.52	-1.10	...
...	...	...	...	...	...	...	...	...	...	...	...
5573	1.05	0.24	0.23	0.76	1.96	-0.06	-0.55	-1.78	-0.76	1.79	...
4818	-1.34	0.73	-0.08	0.98	1.43	-0.06	0.12	0.31	-0.61	-1.53	...
8175	1.05	0.81	-0.08	0.69	-0.69	-0.06	1.20	0.31	1.69	-0.98	...
7587	-0.55	0.52	-0.08	-0.58	-1.27	-0.06	1.31	0.31	0.47	1.12	...
2325	-0.77	0.61	-0.08	-1.17	-0.63	-0.06	0.94	0.31	0.16	-1.34	...

1681 rows × 270 columns

Out[43]:

```
5135    2
1831    0
7746    2
5034    1
1763    1
       ..
6739    2
1508    1
7410    2
5188    0
5266    2
Name: dep_status, Length: 6724, dtype: int32
```

Out[43]:

```
8306    1
159     0
2785    1
7325    2
63      1
       ..
5573    1
4818    2
8175    0
7587    1
2325    0
Name: dep_status, Length: 1681, dtype: int32
```

In [44]:

```
dep_model = LogisticRegression(fit_intercept = True, solver='lbfgs', multi_class = 'ovr', penalty = None,

dep_model.fit(X_train, y_train)

dep_model.score(X_train, y_train)

dep_model.coef_

dep_model.intercept_
```

Out[44]:

```
▾                     LogisticRegression
LogisticRegression(max_iter=1000, multi_class='ovr', penalty=None)
```

Out[44]:

```
0.5684116597263533
```

Out[44]:

```
array([[-1.77135218e-01,  3.51680215e-01, -9.79404090e-02,
         6.48888438e-02, -1.73515191e-01, -1.50481432e-01,
        -3.21256458e-01,  2.41651000e-03, -7.08830378e-02,
        -2.03322222e-01,  1.54520179e-01,  4.26887065e-01,
         7.30103110e-02, -5.14167330e-03, -3.66915817e-02,
        -1.09301915e-01,  1.73459079e-02, -1.36091429e-01,
         9.03931281e-02, -1.04621986e-02, -1.20279865e-02,
         2.41390914e-02,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
        -1.01810626e+00, -1.34288463e+00, -3.01804881e+00,
        -3.38892609e+00, -1.54361720e+00, -1.50197082e+00,
        -9.36254061e-01, -1.02529161e+00, -3.36584012e-01,
        -8.05112872e-02,  2.49039169e-01,  2.90658735e-01,
```

In [45]:

```
dep_model.score(X_test,y_test)
```

Out[45]:

```
0.5234979179060083
```

In [46]:

```
dep_model_output = pd.DataFrame(dep_model.predict(X_test), index = X_test.index, columns = ['pred_dep_stat
dep_model_output = dep_model_output.merge(y_test, left_index = True, right_index = True)
dep_model_output.head(20)
```

Out[46]:

	pred_dep_status	dep_status
8306	1	1
159	1	0
2785	1	1
7325	2	2
63	1	1
2394	1	1
3477	0	0
6905	0	0
3485	0	1
86	1	0
3001	1	1
7693	0	2
8128	1	1
3772	1	1
3718	1	0
2246	1	2
3261	1	1
1828	1	2
3947	1	2
8258	1	2

In [47]:

```
from sklearn.tree import DecisionTreeClassifier
dep_clf = DecisionTreeClassifier(random_state=50, min_samples_leaf = 4)

dep_clf = dep_clf.fit(X_train, y_train)
dep_clf.score(X_train, y_train)

#dep_clf.feature_importances_
dep_clf_output = pd.DataFrame(dep_clf.predict(X_test), index = X_test.index, columns = ['pred_arr_status']
dep_clf_output = dep_clf_output.merge(y_test, left_index = True, right_index = True)
dep_clf_output.head(20)
dep_clf.score(X_test, y_test)
```

Out[47]:

```
0.8190065437239739
```

Out[47]:

	pred_arr_status	dep_status
8306	1	1
159	1	0
2785	1	1
7325	2	2
63	1	1
2394	1	1
3477	0	0
6905	1	0
3485	1	1
86	2	0
3001	0	1
7693	0	2
8128	1	1
3772	1	1
3718	1	0
2246	1	2
3261	1	1
1828	1	2
3947	1	2
8258	0	2

```
Out[47]: 0.41939321832242715
```

In [48]:

```
dep_rf = RandomForestClassifier(random_state=50, min_samples_leaf = 4, max_features = "sqrt", n_estimators

dep_rf = dep_rf.fit(X_train, y_train)
dep_rf.score(X_train, y_train)

# rf.feature_importances_
feat_imp = pd.Series(dep_rf.feature_importances_, X_train.columns.values).sort_values(ascending=False)
feat_imp_table = pd.DataFrame(feat_imp)
feat_imp_table.head()

dep_rf_output = pd.DataFrame(dep_rf.predict(X_test), index = X_test.index, columns = ['pred_Y'])

dep_rf_output.head()
dep_rf_output = dep_rf_output.merge(y_test, left_index = True, right_index = True)
dep_rf_output.head()
print('Fraction of correct classification ')
dep_rf.score(X_test, y_test)
```

Out[48]:

```
0.7958060678167758
```

Out[48]:

	0
dep_pres	0.05
dep_dewpt	0.05
dep_temp	0.05
arr_dewpt	0.05
arr_temp	0.04

Out[48]:

	pred_Y
8306	1
159	1
2785	1
7325	1
63	1

Out[48]:

	pred_Y	dep_status
8306	1	1
159	1	0
2785	1	1
7325	1	2
63	1	1

```
Fraction of correct classification
```

Out[48]:
```
0.5068411659726353
```

In [49]:
```
dep_gb = GradientBoostingClassifier(random_state=50, min_samples_split = 8, min_samples_leaf = 4, n_estima

dep_gb = dep_gb.fit(X_train, y_train)
dep_gb.score(X_train, y_train)
```

Out[49]:
```
0.7007733491969066
```

In [50]:
```
dep_gb.score(X_test,y_test)
```

Out[50]:
```
0.5092207019631172
```

Training to predict arrival status with departure status

In [51]:
```
arr_data.columns
```

Out[51]:
```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_clouds', 'dep_dewpt',
       'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [52]:

```
su_data.columns
```

Out[52]:

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [53]:
```
su_data.dtypes
```

Out[53]:
```
dep_hour             category
dep_day              category
Origin_Airport       category
arr_hour             category
arr_day              category
dep_min              category
arr_min              category
arr_status              int32
dep_status              int32
dep_clouds              int64
dep_dewpt             float64
dep_precip            float64
dep_pres                int64
dep_rh                  int64
dep_snow              float64
dep_temp              float64
dep_vis                 int64
dep_weather.code     category
dep_wind_dir            int64
dep_wind_gust_spd     float64
dep_wind_spd          float64
arr_clouds              int64
arr_dewpt             float64
arr_precip            float64
arr_pres                int64
arr_rh                  int64
arr_snow              float64
arr_temp              float64
arr_vis                 int64
arr_weather.code     category
arr_wind_dir            int64
arr_wind_gust_spd     float64
arr_wind_spd          float64
dtype: object
```

In [54]:
```
su_data['dep_status']= pd.Categorical(su_data['dep_status'], categories = [0,1,2])
```

In [55]:

```
su_data.dtypes
su_data.columns
```

Out[55]:

```
dep_hour             category
dep_day              category
Origin_Airport       category
arr_hour             category
arr_day              category
dep_min              category
arr_min              category
arr_status              int32
dep_status           category
dep_clouds              int64
dep_dewpt             float64
dep_precip            float64
dep_pres                int64
dep_rh                  int64
dep_snow              float64
dep_temp              float64
dep_vis                 int64
dep_weather.code     category
dep_wind_dir            int64
dep_wind_gust_spd     float64
dep_wind_spd          float64
arr_clouds              int64
arr_dewpt             float64
arr_precip            float64
arr_pres                int64
arr_rh                  int64
arr_snow              float64
arr_temp              float64
arr_vis                 int64
arr_weather.code     category
arr_wind_dir            int64
arr_wind_gust_spd     float64
arr_wind_spd          float64
dtype: object
```

Out[55]:

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [56]:

```python
su_data = pd.get_dummies(su_data, drop_first = True)
su_data.head()
```

Out[56]:

	arr_status	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	...	arr_weathei
0	1	100	-2.80	0.00	989	88	0.00	-1.10	11	320	...	
1	2	100	-1.20	0.25	985	96	8.50	-0.60	2	20	...	
2	2	100	-0.30	0.25	985	92	4.00	0.80	6	255	...	
3	0	100	-2.00	0.00	984	73	0.00	2.40	16	255	...	
4	0	100	-6.30	0.00	995	56	0.00	1.60	16	235	...	

5 rows × 273 columns

In [57]:

```
X_train, X_test, y_train, y_test = train_test_split(su_data.drop(columns = ['arr_status']), su_data['arr_s

X_train
X_test
y_train
y_test
```

Out[57]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
4212	87	11.10	0.00	1027	76	0.00	15.30	16	155	10.00	...
3356	25	6.60	0.00	1024	58	0.00	14.80	16	330	6.00	...
7366	25	16.90	0.00	1013	40	0.00	32.20	16	180	8.80	...
151	95	23.50	16.00	985	62	0.00	31.70	16	185	19.50	...
4874	100	17.70	0.00	1008	90	0.00	19.40	16	140	10.00	...
...	...	...	...	...	...	...	...	...	...	...	...
3785	43	-10.70	0.00	1029	42	0.00	0.70	16	280	8.50	...
7727	25	-8.10	0.00	1015	26	0.00	10.60	16	310	12.40	...
301	40	20.70	0.00	985	75	0.00	25.40	16	175	10.40	...
2076	87	4.00	0.00	993	23	0.00	26.90	16	100	6.00	...
7121	87	-2.20	0.00	1010	54	0.00	6.40	16	320	15.80	...

6724 rows × 272 columns

Out[57]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
5077	100	8.30	0.00	1006	77	0.00	12.20	16	350	12.20	...
4929	100	12.10	0.00	1021	93	0.00	13.30	5	35	8.40	...
6164	59	-13.40	0.00	1025	36	0.00	-0.10	16	330	5.55	...
316	87	6.00	0.00	990	67	0.00	12.00	16	325	11.40	...
8344	50	16.40	0.00	1016	50	0.00	27.80	16	60	4.40	...
...	...	...	...	...	...	...	...	...	...	...	...
2045	0	-3.60	0.00	990	25	0.00	16.40	16	60	7.20	...
6260	78	-5.40	0.00	1014	44	0.00	5.90	16	310	12.00	...
6959	78	10.60	0.00	1006	69	0.00	16.30	16	235	8.00	...
5651	78	20.50	0.00	1013	72	0.00	26.00	16	250	4.00	...
6051	100	8.30	0.00	1009	100	0.00	8.30	2	175	9.20	...

1681 rows × 272 columns

Out[57]:

```
4212    1
3356    0
7366    1
151     0
4874    0
       ..
3785    0
7727    0
301     2
2076    2
7121    0
Name: arr_status, Length: 6724, dtype: int32
```

```
Out[57]: 5077    1
         4929    0
         6164    0
         316     2
         8344    2
                ..
         2045    0
         6260    2
         6959    0
         5651    2
         6051    0
         Name: arr_status, Length: 1681, dtype: int32
```

In [58]:

```
#storing unscaled data
X_test_us = X_test
from sklearn.preprocessing import StandardScaler
sc2 = StandardScaler()
X_train = pd.DataFrame(sc2.fit_transform(X_train), columns = X_train.columns, index = X_train.index)
X_test = pd.DataFrame(sc2.transform(X_test), columns = X_test.columns, index = X_test.index)
X_train
X_test
y_train
y_test
```

Out[58]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
4212	0.63	0.33	-0.08	1.44	0.69	-0.06	-0.02	0.31	-0.40	0.72	...
3356	-1.35	-0.12	-0.08	1.21	-0.26	-0.06	-0.07	0.31	1.39	-0.49	...
7366	-1.35	0.91	-0.08	0.40	-1.21	-0.06	1.72	0.31	-0.15	0.35	...
151	0.89	1.57	1.51	-1.69	-0.05	-0.06	1.67	0.31	-0.09	3.59	...
4874	1.05	0.99	-0.08	0.02	1.43	-0.06	0.40	0.31	-0.56	0.72	...
...	...	...	...	...	...	...	...	...	...	...	...
3785	-0.78	-1.85	-0.08	1.59	-1.11	-0.06	-1.53	0.31	0.88	0.26	...
7727	-1.35	-1.59	-0.08	0.55	-1.95	-0.06	-0.50	0.31	1.18	1.44	...
301	-0.87	1.29	-0.08	-1.69	0.64	-0.06	1.02	0.31	-0.20	0.84	...
2076	0.63	-0.38	-0.08	-1.09	-2.11	-0.06	1.18	0.31	-0.97	-0.49	...
7121	0.63	-1.00	-0.08	0.17	-0.47	-0.06	-0.94	0.31	1.29	2.47	...

6724 rows × 272 columns

Out[58]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
5077	1.05	0.05	-0.08	-0.12	0.74	-0.06	-0.34	0.31	1.59	1.38	...
4929	1.05	0.43	-0.08	0.99	1.59	-0.06	-0.23	-3.57	-1.63	0.23	...
6164	-0.27	-2.12	-0.08	1.29	-1.43	-0.06	-1.61	0.31	1.39	-0.63	...
316	0.63	-0.18	-0.08	-1.31	0.21	-0.06	-0.36	0.31	1.34	1.14	...
8344	-0.55	0.86	-0.08	0.62	-0.69	-0.06	1.27	0.31	-1.37	-0.98	...
...	...	...	...	...	...	...	...	...	...	...	...
2045	-2.16	-1.14	-0.08	-1.31	-2.01	-0.06	0.09	0.31	-1.37	-0.13	...
6260	0.34	-1.32	-0.08	0.47	-1.00	-0.06	-0.99	0.31	1.18	1.32	...
6959	0.34	0.28	-0.08	-0.12	0.32	-0.06	0.08	0.31	0.42	0.11	...
5651	0.34	1.27	-0.08	0.40	0.48	-0.06	1.08	0.31	0.57	-1.10	...
6051	1.05	0.05	-0.08	0.10	1.96	-0.06	-0.74	-4.62	-0.20	0.47	...

1681 rows × 272 columns

Out[58]:

```
4212    1
3356    0
7366    1
151     0
4874    0
       ..
3785    0
7727    0
301     2
2076    2
7121    0
Name: arr_status, Length: 6724, dtype: int32
```

Out[58]:

```
5077    1
4929    0
6164    0
316     2
8344    2
       ..
2045    0
6260    2
6959    0
5651    2
6051    0
Name: arr_status, Length: 1681, dtype: int32
```

In [59]:

```
arr_model2 = LogisticRegression(fit_intercept = True, solver='lbfgs', multi_class = 'ovr', penalty = None,


arr_model2.fit(X_train, y_train)

# The following gives the mean accuracy on the given data and labels
arr_model2.score(X_train, y_train)

# This is the coefficient Beta_1, ..., Beta_7
arr_model2.coef_

# This is the coefficient Beta_0
arr_model2.intercept_
```

Out[59]:

```
▾                    LogisticRegression

LogisticRegression(max_iter=1000, multi_class='ovr', penalty=None)
```

Out[59]:

```
0.7424152290303391
```

Out[59]:

```
array([[-5.50415985e-02,  8.64803695e-01, -7.56792048e-01,
        -3.43117994e-03, -4.31465561e-01, -4.12132283e-01,
        -8.34248097e-01,  1.58800678e-01,  2.45845338e-02,
        -2.31261267e-01,  1.01806330e-01,  2.15299257e-01,
        -6.83855245e-01, -6.38379873e-01,  1.51740233e-02,
         1.74343936e-01,  1.37610586e-02,  6.39923309e-01,
         1.25226870e-01, -1.36907563e-01,  1.15955643e-02,
        -4.46622884e-02,  0.00000000e+00,  0.00000000e+00,
         0.00000000e+00,  0.00000000e+00,  0.00000000e+00,
         3.98716335e+00,  5.33568346e+00,  9.50914734e+00,
         9.88184790e+00,  4.69660100e+00,  4.79111274e+00,
         3.39976719e+00,  3.88689860e+00,  1.45447320e+00,
         3.81282642e-01, -8.71697925e-01, -1.00122428e+00,
```

In [60]:

```
arr_model2.score(X_test,y_test)
```

Out[60]:

```
0.7067221891731112
```

In [61]:

```
from sklearn.tree import DecisionTreeClassifier
arr_clf2 = DecisionTreeClassifier(random_state=50, min_samples_leaf = 3)

arr_clf2 = arr_clf2.fit(X_train, y_train)
arr_clf2.score(X_train, y_train)

#arr_clf2.feature_importances_
arr_clf2_output = pd.DataFrame(arr_clf2.predict(X_test), index = X_test.index, columns = ['pred_arr_status
arr_clf2_output = arr_clf2_output.merge(y_test, left_index = True, right_index = True)
arr_clf2_output.head(20)
arr_clf2.score(X_test, y_test)
```

Out[61]:

```
0.9006543723973826
```

Out[61]:

	pred_arr_status	arr_status
5077	0	1
4929	0	0
6164	1	0
316	0	2
8344	2	2
1790	0	1
4682	0	0
2043	1	0
2633	0	0
4492	2	2
2057	0	0
4985	1	2
4698	0	0
1502	0	0
1275	0	0
7096	0	2
4734	0	0
7670	0	0
2688	0	0
672	1	1

```
Out[61]: 0.6168947055324212
```

In [62]:
```
arr_rf2 = RandomForestClassifier(random_state=50, min_samples_leaf = 4, max_features = "sqrt", n_estimator

arr_rf2 = arr_rf2.fit(X_train, y_train)
arr_rf2.score(X_train, y_train)

# rf.feature_importances_
feat_imp = pd.Series(arr_rf2.feature_importances_, X_train.columns.values).sort_values(ascending=False)
feat_imp_table = pd.DataFrame(feat_imp)
feat_imp_table.head()

arr_rf2_output = pd.DataFrame(arr_rf2.predict(X_test), index = X_test.index, columns = ['pred_Y'])

arr_rf2_output.head()
arr_rf2_output = arr_rf2_output.merge(y_test, left_index = True, right_index = True)
arr_rf2_output.head()
print('Fraction of correct classification ')
arr_rf2.score(X_test, y_test)
```

Out[62]:
```
0.7984830458060678
```

Out[62]:

	0
dep_status_2	0.29
dep_status_1	0.06
dep_dewpt	0.03
dep_temp	0.03
arr_rh	0.03

Out[62]:

	pred_Y
5077	0
4929	0
6164	0
316	0
8344	2

Out[62]:

	pred_Y	arr_status
5077	0	1
4929	0	0
6164	0	0
316	0	2
8344	2	2

```
Fraction of correct classification
```

Out[62]:
```
0.7079119571683522
```

In [63]:
```
arr_gb2 = GradientBoostingClassifier(random_state=50, min_samples_split = 8, min_samples_leaf = 4, n_estim

arr_gb2 = arr_gb2.fit(X_train, y_train)
arr_gb2.score(X_train, y_train)
```

Out[63]:
```
0.855145746579417
```

In [64]:
```

arr_gb2.score(X_test,y_test)
```

Out[64]:
```
0.6977989292088043
```

Checking hybrid model on test data

Applying departure status prediction logistic regression model

In [65]:
```
X_test_us.drop(columns = ['dep_status_1','dep_status_2'],inplace = True)
X_test_s = pd.DataFrame(sc.transform(X_test_us), columns = X_test_us.columns, index = X_test_us.index)
```

In [66]:

```
dep_model_output = pd.DataFrame(dep_model.predict(X_test_s), index = X_test_s.index, columns = ['dep_statu
dep_model_output = dep_model_output.merge(X_test_us, left_index = True, right_index = True)
dep_model_output.head(20)
```

Out[66]:

	dep_status	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	...	arr_we
5077	1	100	8.30	0.00	1006	77	0.00	12.20	16	350	...	
4929	1	100	12.10	0.00	1021	93	0.00	13.30	5	35	...	
6164	0	59	-13.40	0.00	1025	36	0.00	-0.10	16	330	...	
316	1	87	6.00	0.00	990	67	0.00	12.00	16	325	...	
8344	1	50	16.40	0.00	1016	50	0.00	27.80	16	60	...	
1790	1	87	-2.30	0.00	988	72	0.00	2.20	16	310	...	
4682	1	50	21.40	0.00	1008	52	0.00	32.50	16	180	...	
2043	1	100	4.20	0.00	984	63	0.00	11.00	16	35	...	
2633	1	0	-14.00	0.00	1000	69	0.00	-9.40	16	265	...	
4492	1	95	21.50	0.00	1012	76	0.00	26.10	16	90	...	
2057	1	87	7.80	0.00	986	23	0.00	31.40	16	175	...	
4985	1	25	9.20	0.00	1029	81	0.00	12.40	16	45	...	
4698	1	100	20.20	0.06	1015	94	0.00	21.20	4	120	...	
1502	1	100	0.70	0.00	1003	73	0.00	5.20	16	110	...	
1275	1	78	8.80	0.00	988	54	0.00	18.30	16	190	...	
7096	2	100	12.70	0.25	1023	96	0.00	13.30	6	120	...	
4734	1	59	17.80	0.00	1019	77	0.00	22.00	16	230	...	
7670	2	87	12.70	0.00	1022	80	0.00	16.10	16	10	...	
2688	0	87	1.70	0.00	1009	89	0.00	3.30	11	110	...	
672	1	100	-0.20	0.00	975	63	0.00	6.30	16	225	...	

20 rows × 271 columns

applying arrival status prediction random forest model

In [67]:
```
dep_model_output['dep_status']= pd.Categorical(dep_model_output['dep_status'], categories = [0,1,2])
```

In [68]:
```
dep_model_output = pd.get_dummies(dep_model_output, columns=['dep_status'],drop_first = True)
```

In [69]:
```
dep_model_output = dep_model_output[X_test.columns]
dep_model_output.head()
```

Out[69]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...
5077	100	8.30	0.00	1006	77	0.00	12.20	16	350	12.20	...
4929	100	12.10	0.00	1021	93	0.00	13.30	5	35	8.40	...
6164	59	-13.40	0.00	1025	36	0.00	-0.10	16	330	5.55	...
316	87	6.00	0.00	990	67	0.00	12.00	16	325	11.40	...
8344	50	16.40	0.00	1016	50	0.00	27.80	16	60	4.40	...

5 rows × 272 columns

In [70]:
```
dep_model_output = pd.DataFrame(sc2.transform(dep_model_output), columns = dep_model_output.columns, index
```

In [71]:
```
arr_rf2.score(dep_model_output,y_test)
```

Out[71]:
```
0.5621653777513385
```

Checking hybrid model on whole data

applying departure status prediction logistic model

In [72]:

```
arr_data_cut = arr_data.drop(columns=['arr_status'])
arr_data_cut.dtypes
arr_data_cut.columns
```

```
Out[72]: dep_hour             category
         dep_day              category
         Origin_Airport       category
         arr_hour             category
         arr_day              category
         dep_min              category
         arr_min              category
         dep_clouds              int64
         dep_dewpt             float64
         dep_precip            float64
         dep_pres                int64
         dep_rh                  int64
         dep_snow              float64
         dep_temp              float64
         dep_vis                 int64
         dep_weather.code     category
         dep_wind_dir            int64
         dep_wind_gust_spd     float64
         dep_wind_spd          float64
         arr_clouds              int64
         arr_dewpt             float64
         arr_precip            float64
         arr_pres                int64
         arr_rh                  int64
         arr_snow              float64
         arr_temp              float64
         arr_vis                 int64
         arr_weather.code     category
         arr_wind_dir            int64
         arr_wind_gust_spd     float64
         arr_wind_spd          float64
         dtype: object
```

```
Out[72]: Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
                'dep_min', 'arr_min', 'dep_clouds', 'dep_dewpt', 'dep_precip',
                'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
                'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
                'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
                'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
                'arr_wind_gust_spd', 'arr_wind_spd'],
               dtype='object')
```

In [73]:
```
arr_data_cut.columns
```

Out[73]:
```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'dep_clouds', 'dep_dewpt', 'dep_precip',
       'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [74]:
```
arr_data_cut = arr_data_cut[['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'dep_clouds', 'dep_dewpt',
       'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd']]
```

In [75]:
```
arr_data_cut = pd.get_dummies(arr_data_cut, drop_first = True)
arr_data_cut.head()
```

Out[75]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...	ai
0	100	-2.80	0.00	989	88	0.00	-1.10	11	320	6.80	...	
1	100	-1.20	0.25	985	96	8.50	-0.60	2	20	15.90	...	
2	100	-0.30	0.25	985	92	4.00	0.80	6	255	8.20	...	
3	100	-2.00	0.00	984	73	0.00	2.40	16	255	10.40	...	
4	100	-6.30	0.00	995	56	0.00	1.60	16	235	7.60	...	

5 rows × 270 columns

In [76]:
```
arr_data_cut = pd.DataFrame(sc.transform(arr_data_cut), columns = arr_data_cut.columns, index = arr_data_c
```

In [77]:

```
dep_model_output = pd.DataFrame(dep_model.predict(arr_data_cut), index = arr_data_cut.index, columns = ['d
dep_model_output = dep_model_output.merge(arr_data, left_index = True, right_index = True)
dep_model_output.head(20)
```

Out[77]:

	dep_status	dep_hour	dep_day	Origin_Airport	arr_hour	arr_day	dep_min	arr_min	arr_status	dep_clouds	...	arr_precip	ar
0	0	7	5	ORD	10	5	55	47	1	100	...	2.25	
1	1	15	5	ORD	17	5	0	48	2	100	...	2.25	
2	1	15	5	ORD	17	5	0	48	2	100	...	2.25	
3	1	15	5	ORD	17	5	0	48	0	100	...	0.00	
4	1	15	5	ORD	17	5	0	48	0	100	...	0.00	
5	1	19	0	ORD	22	0	29	16	1	87	...	0.00	
6	1	15	1	ORD	17	1	6	53	0	78	...	0.00	
7	1	15	2	ORD	17	2	6	53	1	62	...	0.00	
8	1	15	3	ORD	17	3	6	53	1	87	...	0.00	
9	1	15	4	ORD	17	4	6	53	1	50	...	0.00	
10	1	15	6	ORD	17	6	6	53	1	100	...	0.00	
11	1	15	0	ORD	17	0	6	53	0	78	...	0.06	
12	1	15	1	ORD	17	1	6	53	0	87	...	0.00	
13	1	15	2	ORD	17	2	6	53	1	87	...	0.00	
14	1	15	3	ORD	17	3	6	53	0	59	...	0.00	
15	1	15	4	ORD	17	4	6	53	1	100	...	0.00	
16	1	15	6	ORD	17	6	6	53	1	25	...	2.25	
17	1	15	0	ORD	17	0	6	53	1	87	...	0.00	
18	1	15	1	ORD	17	1	6	53	1	0	...	0.00	
19	1	15	2	ORD	17	2	6	53	1	100	...	0.00	

20 rows × 33 columns

In [78]:

```
dep_model_output.columns
```

Out[78]:

```
Index(['dep_status', 'dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour',
       'arr_day', 'dep_min', 'arr_min', 'arr_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [79]:

```
dep_model_output.dtypes
```

Out[79]:

```
dep_status              int32
dep_hour             category
dep_day              category
Origin_Airport       category
arr_hour             category
arr_day              category
dep_min              category
arr_min              category
arr_status              int32
dep_clouds              int64
dep_dewpt             float64
dep_precip            float64
dep_pres                int64
dep_rh                  int64
dep_snow              float64
dep_temp              float64
dep_vis                 int64
dep_weather.code     category
dep_wind_dir            int64
dep_wind_gust_spd     float64
dep_wind_spd          float64
arr_clouds              int64
arr_dewpt             float64
arr_precip            float64
arr_pres                int64
arr_rh                  int64
arr_snow              float64
arr_temp              float64
arr_vis                 int64
arr_weather.code     category
arr_wind_dir            int64
arr_wind_gust_spd     float64
arr_wind_spd          float64
dtype: object
```

applying arrival status prediction random forest model

In [80]:
```
dep_model_output['dep_status']= pd.Categorical(dep_model_output['dep_status'], categories = [0,1,2])
```

In [81]:

```
dep_model_output = dep_model_output[['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_status', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd']]
dep_model_output.dtypes
```

Out[81]:

```
dep_hour             category
dep_day              category
Origin_Airport       category
arr_hour             category
arr_day              category
dep_min              category
arr_min              category
arr_status              int32
dep_status           category
dep_clouds              int64
dep_dewpt             float64
dep_precip            float64
dep_pres                int64
dep_rh                  int64
dep_snow              float64
dep_temp              float64
dep_vis                 int64
dep_weather.code     category
dep_wind_dir            int64
dep_wind_gust_spd     float64
dep_wind_spd          float64
arr_clouds              int64
arr_dewpt             float64
arr_precip            float64
arr_pres                int64
arr_rh                  int64
arr_snow              float64
arr_temp              float64
arr_vis                 int64
arr_weather.code     category
arr_wind_dir            int64
arr_wind_gust_spd     float64
arr_wind_spd          float64
dtype: object
```

In [82]:

```
arr_data2 = dep_model_output.drop(columns = ['arr_status'])
```

In [83]:

```
arr_data2 = pd.get_dummies(arr_data2, drop_first = True)
arr_data2.head()
```

Out[83]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...	ar
0	100	-2.80	0.00	989	88	0.00	-1.10	11	320	6.80	...	
1	100	-1.20	0.25	985	96	8.50	-0.60	2	20	15.90	...	
2	100	-0.30	0.25	985	92	4.00	0.80	6	255	8.20	...	
3	100	-2.00	0.00	984	73	0.00	2.40	16	255	10.40	...	
4	100	-6.30	0.00	995	56	0.00	1.60	16	235	7.60	...	

5 rows × 272 columns

In [84]:

```

arr_data2 = pd.DataFrame(sc2.transform(arr_data2), columns = arr_data2.columns, index = arr_data2.index)
```

In [85]:

```
arr_rf2.score(arr_data2,dep_model_output['arr_status'])
```

Out[85]:

```
0.6135633551457466
```

predicting data with hybrid model

In [86]:

```
pred_data1 = pd.read_csv('pred_data1.csv')
pred_data1.head()
pred_data1.dtypes
```

Out[86]:

	Unnamed: 0	dep_hour	dep_day	Origin_Airport	arr_hour	arr_day	dep_min	arr_min	arr_clouds	arr_dewpt	...	dep_precip	dep_
0	0	18	4	ORD	21	4	52	47	69	8.00	...	0.00	9
1	2	13	4	JFK	14	4	34	51	84	7.20	...	0.00	1,0
2	4	11	4	MCO	14	4	35	20	84	7.20	...	0.00	1,0
3	6	18	5	ORD	21	5	52	47	23	-2.40	...	0.00	9
4	8	13	5	JFK	14	5	25	41	71	-1.20	...	0.00	1,0

5 rows × 32 columns

```
Out[86]: Unnamed: 0             int64
         dep_hour               int64
         dep_day                int64
         Origin_Airport        object
         arr_hour               int64
         arr_day                int64
         dep_min                int64
         arr_min                int64
         arr_clouds             int64
         arr_dewpt            float64
         arr_precip           float64
         arr_pres             float64
         arr_rh                 int64
         arr_snow               int64
         arr_temp             float64
         arr_vis              float64
         arr_weather.code       int64
         arr_wind_dir           int64
         arr_wind_gust_spd    float64
         arr_wind_spd         float64
         dep_clouds             int64
         dep_dewpt            float64
         dep_precip           float64
         dep_pres             float64
         dep_rh                 int64
         dep_snow               int64
         dep_temp             float64
         dep_vis              float64
         dep_weather.code       int64
         dep_wind_dir           int64
         dep_wind_gust_spd    float64
         dep_wind_spd         float64
         dtype: object
```

In [87]:

```
pred_data1['dep_min'] = pred_data1['dep_min'].astype('object')
pred_data1['arr_min'] = pred_data1['arr_min'].astype('object')
pred_data1['dep_hour'] = pred_data1['dep_hour'].astype('object')
pred_data1['dep_day'] = pred_data1['dep_day'].astype('object')
pred_data1['arr_hour'] = pred_data1['arr_hour'].astype('object')
pred_data1['arr_day'] = pred_data1['arr_day'].astype('object')
pred_data1['dep_weather.code'] = pred_data1['dep_weather.code'].astype('object')
pred_data1['arr_weather.code'] = pred_data1['arr_weather.code'].astype('object')
pred_data1.drop(columns=['Unnamed: 0'],inplace=True)
pred_data1 = pred_data1[['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'arr_clouds', 'arr_dewpt',
       'arr_precip', 'arr_pres', 'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis',
       'arr_weather.code', 'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd',
       'dep_clouds', 'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh',
       'dep_snow', 'dep_temp', 'dep_vis', 'dep_weather.code', 'dep_wind_dir',
       'dep_wind_gust_spd', 'dep_wind_spd']]

pred_data1.dtypes
```

Out[87]:

```
dep_hour              object
dep_day               object
Origin_Airport        object
arr_hour              object
arr_day               object
dep_min               object
arr_min               object
arr_clouds             int64
arr_dewpt            float64
arr_precip           float64
arr_pres             float64
arr_rh                 int64
arr_snow               int64
arr_temp             float64
arr_vis              float64
arr_weather.code      object
arr_wind_dir           int64
arr_wind_gust_spd    float64
arr_wind_spd         float64
dep_clouds             int64
dep_dewpt            float64
dep_precip           float64
dep_pres             float64
dep_rh                 int64
dep_snow               int64
dep_temp             float64
dep_vis              float64
dep_weather.code      object
dep_wind_dir           int64
dep_wind_gust_spd    float64
dep_wind_spd         float64
dtype: object
```

In [88]:

```
pred_data1['dep_hour'] = pd.Categorical(pred_data1['dep_hour'], categories=[i for i in range(24)])
pred_data1['dep_day'] = pd.Categorical(pred_data1['dep_day'], categories=[i for i in range(7)])
pred_data1['dep_min'] = pd.Categorical(pred_data1['dep_min'], categories=[i for i in range(60)])
pred_data1['arr_hour'] = pd.Categorical(pred_data1['arr_hour'], categories=[i for i in range(24)])
pred_data1['arr_day'] = pd.Categorical(pred_data1['arr_day'], categories=[i for i in range(7)])
pred_data1['arr_min'] = pd.Categorical(pred_data1['arr_min'], categories=[i for i in range(60)])
#su_data['Carrier_Code'] = pd.Categorical(su_data['Carrier_Code'], categories=['AA', 'UA', 'DL', 'B6', 'WN
pred_data1['Origin_Airport'] = pd.Categorical(pred_data1['Origin_Airport'], categories=['ORD', 'JFK', 'MCO
pred_data1['arr_weather.code'] = pd.Categorical(pred_data1['arr_weather.code'], categories=[200,201,202,23
pred_data1['dep_weather.code'] = pd.Categorical(pred_data1['dep_weather.code'], categories=[200,201,202,23
```

In [89]:

```
pred_data1 = pred_data1[['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'dep_clouds', 'dep_dewpt',
       'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd']]
```

In [90]:

```
pred_data1.columns
```

Out[90]:

```
Index(['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'dep_clouds', 'dep_dewpt', 'dep_precip',
       'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp', 'dep_vis',
       'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd', 'dep_wind_spd',
       'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres', 'arr_rh',
       'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code', 'arr_wind_dir',
       'arr_wind_gust_spd', 'arr_wind_spd'],
      dtype='object')
```

In [91]:

```
pred_data = pred_data1
```

applying logistic regression model for departure status

In [92]:

```
pred_data1 = pd.get_dummies(pred_data1, drop_first = True)
pred_data1.head()
pred_data1.dtypes
pred_data1.columns
```

Out[92]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...	ar
0	19	-2.40	0.00	996.50	35	0	12.70	24.00	280	12.50	...	
1	82	4.10	0.00	1,019.50	58	0	12.10	24.00	110	7.20	...	
2	14	19.10	0.00	1,015.00	58	0	28.10	24.00	280	2.40	...	
3	68	-3.20	0.00	994.00	40	0	9.70	24.13	296	6.66	...	
4	66	4.30	0.00	1,014.50	46	0	15.80	24.00	283	5.73	...	

5 rows × 270 columns

Out[92]:

```
dep_clouds                int64
dep_dewpt               float64
dep_precip              float64
dep_pres                float64
dep_rh                    int64
                         ...
arr_weather.code_801       bool
arr_weather.code_802       bool
arr_weather.code_803       bool
arr_weather.code_804       bool
arr_weather.code_900       bool
Length: 270, dtype: object
```

Out[92]:

```
Index(['dep_clouds', 'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh',
       'dep_snow', 'dep_temp', 'dep_vis', 'dep_wind_dir', 'dep_wind_gust_spd',
       ...
       'arr_weather.code_721', 'arr_weather.code_731', 'arr_weather.code_741',
       'arr_weather.code_751', 'arr_weather.code_800', 'arr_weather.code_801',
       'arr_weather.code_802', 'arr_weather.code_803', 'arr_weather.code_804',
       'arr_weather.code_900'],
      dtype='object', length=270)
```

In [93]:

```
from sklearn.preprocessing import StandardScaler
X_test = pd.DataFrame(sc.transform(pred_data1), columns = pred_data1.columns, index = pred_data1.index)
```

In [94]:

```
dep_model_output = pd.DataFrame(dep_model.predict(X_test), index = X_test.index, columns = ['dep_status'])
dep_model_output = dep_model_output.merge(pred_data, left_index = True, right_index = True)
dep_model_output.head(30)
```

Out[94]:

	dep_status	dep_hour	dep_day	Origin_Airport	arr_hour	arr_day	dep_min	arr_min	dep_clouds	dep_dewpt	...	arr_precip	a
0	1	18	4	ORD	21	4	52	47	19	-2.40	...	0.50	
1	2	13	4	JFK	14	4	34	51	82	4.10	...	0.50	
2	2	11	4	MCO	14	4	35	20	14	19.10	...	0.50	
3	1	18	5	ORD	21	5	52	47	68	-3.20	...	0.00	
4	2	13	5	JFK	14	5	25	41	66	4.30	...	0.00	1
5	1	13	5	MCO	16	5	35	25	2	16.30	...	0.00	
6	1	18	6	ORD	21	6	52	47	3	-1.40	...	0.00	
7	2	13	6	JFK	14	6	35	51	64	-1.10	...	0.00	
8	1	11	6	MCO	13	6	5	50	37	18.80	...	0.00	
9	1	18	0	ORD	21	0	52	47	75	1.00	...	0.00	1
10	0	13	0	JFK	14	0	35	51	21	0.80	...	0.00	1
11	1	11	0	MCO	14	0	35	20	50	20.10	...	0.00	1

12 rows × 32 columns

applying random forest model for arrival status prediction

In [95]:
```
dep_model_output['dep_status']= pd.Categorical(dep_model_output['dep_status'], categories = [0,1,2])
```

In [96]:
```
dep_model_output = dep_model_output[['dep_hour', 'dep_day', 'Origin_Airport', 'arr_hour', 'arr_day',
       'dep_min', 'arr_min', 'dep_status', 'dep_clouds',
       'dep_dewpt', 'dep_precip', 'dep_pres', 'dep_rh', 'dep_snow', 'dep_temp',
       'dep_vis', 'dep_weather.code', 'dep_wind_dir', 'dep_wind_gust_spd',
       'dep_wind_spd', 'arr_clouds', 'arr_dewpt', 'arr_precip', 'arr_pres',
       'arr_rh', 'arr_snow', 'arr_temp', 'arr_vis', 'arr_weather.code',
       'arr_wind_dir', 'arr_wind_gust_spd', 'arr_wind_spd']]
dep_model_output.dtypes
```

Out[96]:
```
dep_hour             category
dep_day              category
Origin_Airport       category
arr_hour             category
arr_day              category
dep_min              category
arr_min              category
dep_status           category
dep_clouds              int64
dep_dewpt             float64
dep_precip            float64
dep_pres              float64
dep_rh                  int64
dep_snow                int64
dep_temp              float64
dep_vis               float64
dep_weather.code     category
dep_wind_dir            int64
dep_wind_gust_spd     float64
dep_wind_spd          float64
```

In [97]:

```
arr_data2 = pd.get_dummies(dep_model_output, drop_first = True)
arr_data2.head()
```

Out[97]:

	dep_clouds	dep_dewpt	dep_precip	dep_pres	dep_rh	dep_snow	dep_temp	dep_vis	dep_wind_dir	dep_wind_gust_spd	...	ar
0	19	-2.40	0.00	996.50	35	0	12.70	24.00	280	12.50	...	
1	82	4.10	0.00	1,019.50	58	0	12.10	24.00	110	7.20	...	
2	14	19.10	0.00	1,015.00	58	0	28.10	24.00	280	2.40	...	
3	68	-3.20	0.00	994.00	40	0	9.70	24.13	296	6.66	...	
4	66	4.30	0.00	1,014.50	46	0	15.80	24.00	283	5.73	...	

5 rows × 272 columns

In [98]:

```

arr_data2 = pd.DataFrame(sc2.transform(arr_data2), columns = arr_data2.columns, index = arr_data2.index)
```

In [99]:

```
output = pd.DataFrame(arr_rf2.predict(arr_data2), index = arr_data2.index, columns = ['arr_status'])
```

In [100]:

```
output
```

Out[100]:

```
    arr_status
 0           0
 1           2
 2           2
 3           0
 4           2
 5           0
 6           0
 7           2
 8           0
 9           0
10           0
11           0
```

In [ ]:

```

```