Harvey

March 24, 2019

In [1]:
```
###  THIS WORK IS NOT COMPLETE> WORK IN PROGRESS
#Data Sources:
#Flights: Bureau of Transportation Statistics On-Time data (https://www.transtats.bts.
#Weather: NOAA Daily Summary (https://www.ncdc.noaa.gov/cdo-web/datatools)
#Airport Cordinates: Open Flights (https://openflights.org/data.html)
```

In [2]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

In [3]:
```
dfAug = pd.read_csv('AUG.csv')
dfSep = pd.read_csv('SEP.csv')
df=pd.concat([dfAug,dfSep])
del dfAug
del dfSep
```

```
C:\ProgramData\Anaconda3\lib\site-packages\IPython\core\interactiveshell.py:2785: DtypeWarning
  interactivity=interactivity, compiler=compiler, result=result)
```

In [4]:
```
len(df)
```

Out[4]:
```
969178
```

In [5]:
```
#Dropping unnecessary columns
df.drop(['OP_CARRIER_AIRLINE_ID','OP_UNIQUE_CARRIER','ORIGIN_AIRPORT_SEQ_ID',
            'ORIGIN_STATE_FIPS','DEST_AIRPORT_SEQ_ID','DEST_STATE_FIPS','DEP_DELAY_GROU
           'WHEELS_ON','ARR_DELAY_GROUP','ARR_TIME_BLK','ARR_TIME_BLK','DIV_ACTUAL_ELA
            'DIV1_WHEELS_ON','DIV1_TOTAL_GTIME','DIV1_LONGEST_GTIME','DIV1_TAIL_NUM'],a
```

In [6]:
```
#df.iloc[0:10,10:22]
```

In [7]:
```
df[df['ORIGIN']=='IAH'].iloc[0:10,10:26]
```

Out[7]:

	ORIGIN_CITY_MARKET_ID	ORIGIN	ORIGIN_CITY_NAME	ORIGIN_STATE_ABR	\
16611	31453	IAH	Houston, TX	TX	

```
16688                 31453    IAH      Houston, TX               TX
16748                 31453    IAH      Houston, TX               TX
16758                 31453    IAH      Houston, TX               TX
16942                 31453    IAH      Houston, TX               TX
16958                 31453    IAH      Houston, TX               TX
16980                 31453    IAH      Houston, TX               TX
17048                 31453    IAH      Houston, TX               TX
17093                 31453    IAH      Houston, TX               TX
17183                 31453    IAH      Houston, TX               TX

      ORIGIN_STATE_NM  ORIGIN_WAC  DEST_AIRPORT_ID  DEST_CITY_MARKET_ID DEST  \
16611           Texas          74            11042                30647  CLE
16688           Texas          74            11292                30325  DEN
16748           Texas          74            11292                30325  DEN
16758           Texas          74            10397                30397  ATL
16942           Texas          74            12889                32211  LAS
16958           Texas          74            11193                33105  CVG
16980           Texas          74            11292                30325  DEN
17048           Texas          74            11292                30325  DEN
17093           Texas          74            14100                34100  PHL
17183           Texas          74            11042                30647  CLE

        DEST_CITY_NAME DEST_STATE_ABR DEST_STATE_NM  DEST_WAC  CRS_DEP_TIME  \
16611     Cleveland, OH             OH          Ohio        44          1620
16688        Denver, CO             CO      Colorado        82          1059
16748        Denver, CO             CO      Colorado        82          1936
16758       Atlanta, GA             GA       Georgia        34          1825
16942     Las Vegas, NV             NV        Nevada        85          1620
16958    Cincinnati, OH             KY      Kentucky        52          1515
16980        Denver, CO             CO      Colorado        82          1059
17048        Denver, CO             CO      Colorado        82          1936
17093  Philadelphia, PA             PA  Pennsylvania        23          1718
17183     Cleveland, OH             OH          Ohio        44          1620

       DEP_TIME  DEP_DELAY
16611    1613.0       -7.0
16688    1056.0       -3.0
16748    1933.0       -3.0
16758    1819.0       -6.0
16942    1640.0       20.0
16958    1539.0       24.0
16980    1103.0        4.0
17048    1932.0       -4.0
17093    2135.0      257.0
17183    1609.0      -11.0
```

In [8]:
```
#Extracting flights to and from Houston
houFlights = df[(df['ORIGIN_CITY_MARKET_ID']==31453)|(df['DEST_CITY_MARKET_ID']==31453)
```

```
In [9]: len(houFlights)

Out[9]: 59830

In [10]: houFlights.columns

Out[10]: Index(['YEAR', 'QUARTER', 'MONTH', 'DAY_OF_MONTH', 'DAY_OF_WEEK', 'FL_DATE',
                'OP_CARRIER', 'TAIL_NUM', 'OP_CARRIER_FL_NUM', 'ORIGIN_AIRPORT_ID',
                'ORIGIN_CITY_MARKET_ID', 'ORIGIN', 'ORIGIN_CITY_NAME',
                'ORIGIN_STATE_ABR', 'ORIGIN_STATE_NM', 'ORIGIN_WAC', 'DEST_AIRPORT_ID',
                'DEST_CITY_MARKET_ID', 'DEST', 'DEST_CITY_NAME', 'DEST_STATE_ABR',
                'DEST_STATE_NM', 'DEST_WAC', 'CRS_DEP_TIME', 'DEP_TIME', 'DEP_DELAY',
                'DEP_DEL15', 'TAXI_OUT', 'TAXI_IN', 'CRS_ARR_TIME', 'ARR_TIME',
                'ARR_DELAY', 'ARR_DEL15', 'CANCELLED', 'CANCELLATION_CODE', 'DIVERTED',
                'AIR_TIME', 'DISTANCE', 'DISTANCE_GROUP', 'CARRIER_DELAY',
                'WEATHER_DELAY', 'NAS_DELAY', 'SECURITY_DELAY', 'LATE_AIRCRAFT_DELAY',
                'DIV_AIRPORT_LANDINGS', 'DIV_REACHED_DEST', 'DIV_ARR_DELAY',
                'DIV_DISTANCE', 'DIV1_AIRPORT', 'DIV1_AIRPORT_ID', 'DIV1_WHEELS_OFF',
                'Unnamed: 68'],
               dtype='object')
```

Checking for flights with both Origin and Destination as Houston

```
In [11]: houFlights[(houFlights['ORIGIN_CITY_MARKET_ID']==31453)&(houFlights['DEST_CITY_MARKET_

Out[11]: Empty DataFrame
         Columns: [YEAR, QUARTER, MONTH, DAY_OF_MONTH, DAY_OF_WEEK, FL_DATE, OP_CARRIER, TAIL_N
         Index: []

         [0 rows x 52 columns]
```

There are no flights with both Origin and Destination as Houston

0.1 Feature Engineering

Extract date and weekday

```
In [12]: houFlights['DATE'] = pd.to_datetime(houFlights['FL_DATE'],format='%Y-%m-%d')
         houFlights['DAY_OF_WEEK_NAME'] = houFlights['DATE'].dt.weekday_name

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
```

```
In [13]: houFlights['DEP_DELAY'] = houFlights['DEP_DELAY'].apply(lambda x:0.0 if x<0 else x)
         houFlights['ARR_DELAY'] = houFlights['ARR_DELAY'].apply(lambda x:0.0 if x<0 else x)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
```

Replace airline codes with airline names

```
In [14]: airlineMap = {'UA':'United','WN':'Southwest','EV':'ExpressJet','OO':'SkyWest','NK':'Sp
                       'DL':'Delta','F9':'Frontier','B6':'JetBlue','AS':'Alaska'}
         houFlights['CARRIER_NAME'] =  houFlights['OP_CARRIER'].map(airlineMap)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  This is separate from the ipykernel package so we can avoid doing imports until
```

```
In [15]: #method to set flight status
         def getFlightStatus(args):
             if args[0] == 1:
                 return 'Cancelled'
             elif args[1] == 1:
                 return 'Diverted'
             else:
                 return 'Completed'

         def getCompleted(args):
             if ((int(args[0]) == 1) |( int(args[1]) == 1)):
                 return 0
             else:
                 return 1
```

```
In [16]: houFlights['STATUS'] = houFlights[['CANCELLED','DIVERTED']].apply(getFlightStatus,axis
         houFlights['COMPLETED'] = houFlights[['CANCELLED','DIVERTED']].apply(getCompleted,axis

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
```

```
In [17]: #Inbound/Outbound
         houFlights['INBOUND'] = houFlights['DEST_CITY_NAME'].apply(lambda x: 1 if x == 'Houst

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
```

```
In [18]: houFlights['DEP_HR_BLOCK'] = (houFlights['CRS_DEP_TIME']/100).astype(int)
         houFlights['ARR_HR_BLOCK'] = (houFlights['CRS_ARR_TIME']/100).astype(int)

C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
  """Entry point for launching an IPython kernel.
C:\ProgramData\Anaconda3\lib\site-packages\ipykernel_launcher.py:2: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html
```

0.2 Airport Data

Setting airport longitude and lattitude based on data from Open Flights

```
In [19]: airports = pd.read_csv('airports.csv')
         airports.head()
```

Out[19]:

	ID	Name	City	\
0	1	Goroka Airport	Goroka	
1	2	Madang Airport	Madang	
2	3	Mount Hagen Kagamuga Airport	Mount Hagen	
3	4	Nadzab Airport	Nadzab	
4	5	Port Moresby Jacksons International Airport	Port Moresby	

	Country	Code3	Code4	Lat	Lon	Altitude	TimeZone	DST	\
0	Papua New Guinea	GKA	AYGA	-6.081690	145.391998	5282	10	U	
1	Papua New Guinea	MAG	AYMD	-5.207080	145.789001	20	10	U	
2	Papua New Guinea	HGU	AYMH	-5.826790	144.296005	5388	10	U	
3	Papua New Guinea	LAE	AYNZ	-6.569803	146.725977	239	10	U	
4	Papua New Guinea	POM	AYPY	-9.443380	147.220001	146	10	U	

	TimeZOne	Type	Source
0	Pacific/Port_Moresby	airport	OurAirports
1	Pacific/Port_Moresby	airport	OurAirports
2	Pacific/Port_Moresby	airport	OurAirports
3	Pacific/Port_Moresby	airport	OurAirports
4	Pacific/Port_Moresby	airport	OurAirports

```
In [20]: houFlights = pd.merge(houFlights,airports[['Code3','Lat','Lon']],left_on='ORIGIN',rig
         houFlights = pd.merge(houFlights,airports[['Code3','Lat','Lon']],left_on='DEST',right_
         houFlights.rename(columns={'Lat':'Lat_Ori','Lon':'Lon_Ori'}, inplace=True)
         houFlights.drop(['Code3','Code3_Dest'],axis=1,inplace=True)
```

Adding flight direction

```
In [21]: #Westbound Eastbound
         houFlights['DIRECTION'] = houFlights.apply(lambda x:'EASTBOUND' if (x['Lon_Ori']<x['Lo
```

```
In [22]: def setDivAirport(divApt):
             if (divApt != np.NaN):
                 for  a in airports.items():
                     if(divApt== a['Code3']):
                         print(divApt)
             else:
                 print('None')
```

Plot all inbound flights

```
In [23]: gByOriDest = houFlights[houFlights['INBOUND']==1].groupby(['ORIGIN','Lat_Ori','Lon_Ori
         gByOriDest.rename(columns={0:'Count'}, inplace=True)
```

```
In [24]: from plotly.offline import download_plotlyjs, init_notebook_mode,plot,iplot
         import plotly.graph_objs as go
```

```
import cufflinks as cf
init_notebook_mode(connected=True)
cf.go_offline()
import plotly.plotly as py

airportsMap = [ dict(
        type = 'scattergeo',
        locationmode = 'USA-states',
        lon = gByOriDest['Lon_Ori'],
        lat = gByOriDest['Lat_Ori'],
        hoverinfo = 'text',
        text = gByOriDest['ORIGIN'],
        mode = 'markers',
        marker = dict(
            size=2,
            color='rgb(255, 0, 0)',
            line = dict(
                width=3,
                color='rgba(68, 68, 68, 0)'
            )
        ))]


flight_paths = []
for i in range( len(gByOriDest) ):
    flight_paths.append(
        dict(
            type = 'scattergeo',
            locationmode = 'USA-states',
            lon = [ gByOriDest['Lon_Ori'][i], gByOriDest['Lon_Dest'][i] ],
            lat = [ gByOriDest['Lat_Ori'][i], gByOriDest['Lat_Dest'][i] ],
            mode = 'lines',
            line = dict(
                width = 1,
                color = 'red',
            ),
            opacity = (float(gByOriDest['Count'][i])/float(gByOriDest['Count'].max()))
        )
    )



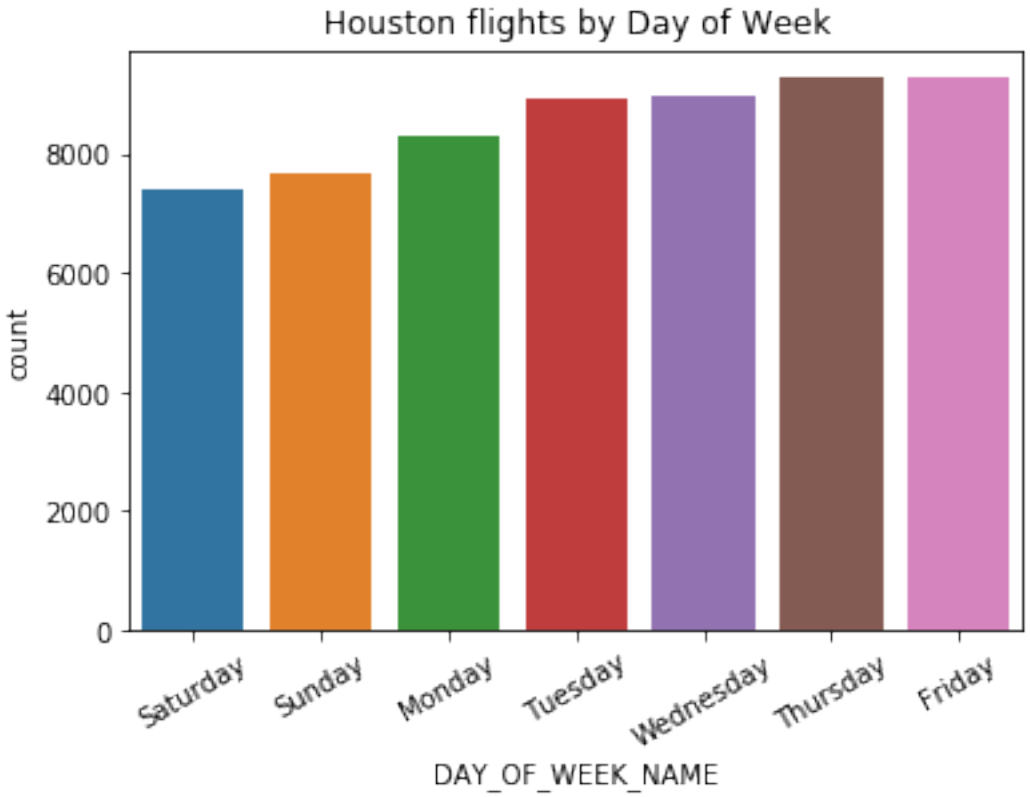
layout = dict(geo={'scope':'usa'},
              showlegend=False)

fig = dict(data = flight_paths +airportsMap,layout=layout)
iplot(fig)
```

We see that most of the United hubs and Southwest mega stations have very high frequencies. The following cities have high frequencies: - Denver - Dallas - Chicago - New York/Newark - Atlanta - San Francisco - Los Angeles

0.2.1 Countplots

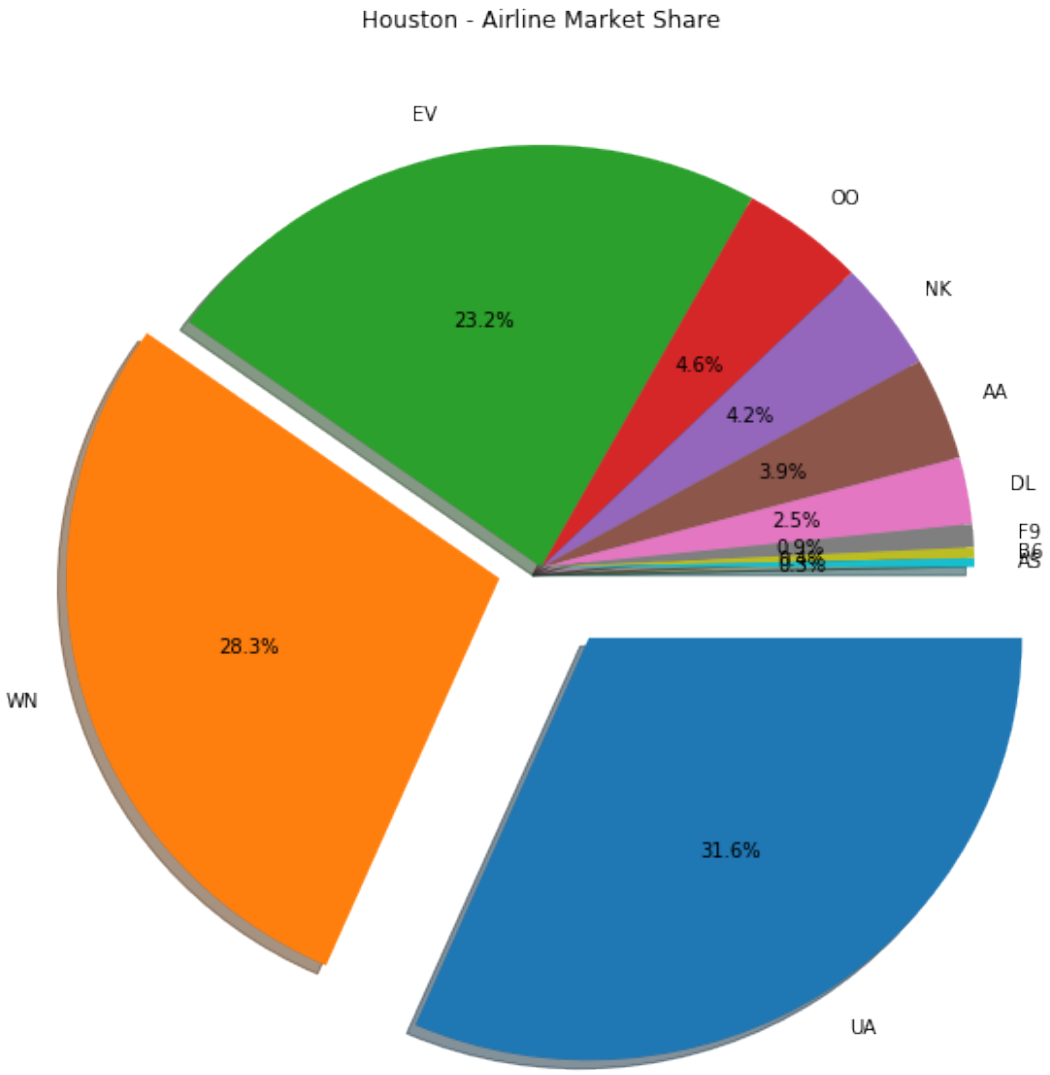
```
In [25]: sns.countplot(data=houFlights,x='DAY_OF_WEEK_NAME')
         plt.xticks(rotation=30)
         plt.title("Houston flights by Day of Week")
         plt.show()
```



There are more flights on weekdays than weekends. We do not have information about international flights. It is possible that airlines fly more international routes on Saturdays due to low domestic demand.

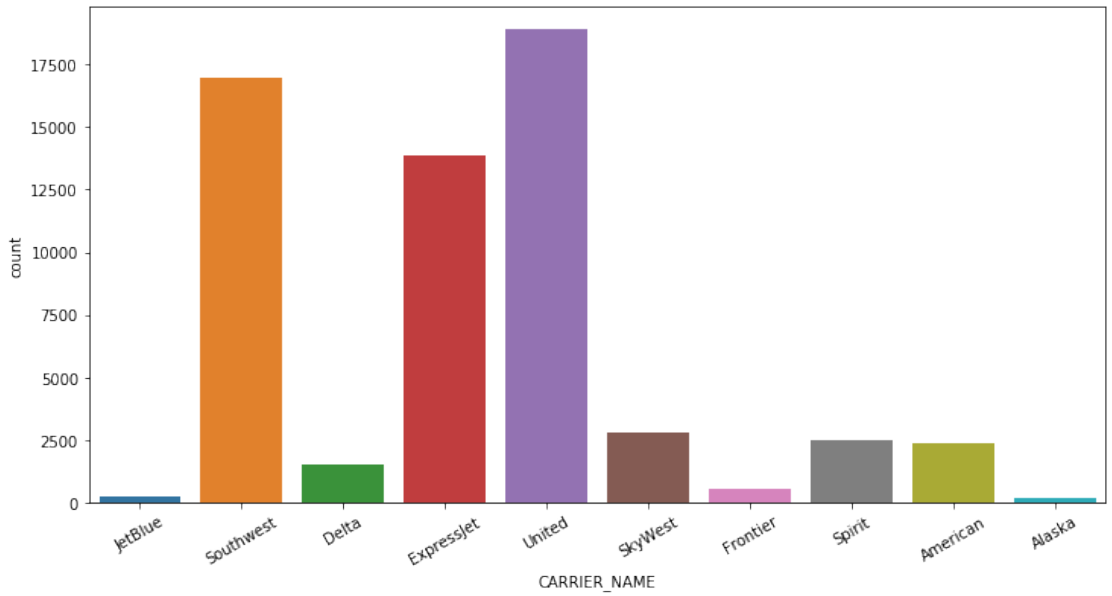
```
In [26]: #houFlights['OP_CARRIER'].value_counts()
```

```
In [27]: airlineCounts = houFlights['OP_CARRIER'].value_counts().to_frame().reset_index()
         airlineCounts.rename(columns={'index':'Carrier','OP_CARRIER':'AirlineCount'}, inplace=
         plt.figure(figsize=(10,10))
         explode = (0.2, .1, 0, 0, 0, 0,0,0,0,0)
         plt.pie(airlineCounts['AirlineCount'], labels=airlineCounts['Carrier'],explode=explode
         plt.title('Houston - Airline Market Share')
         plt.show()
```

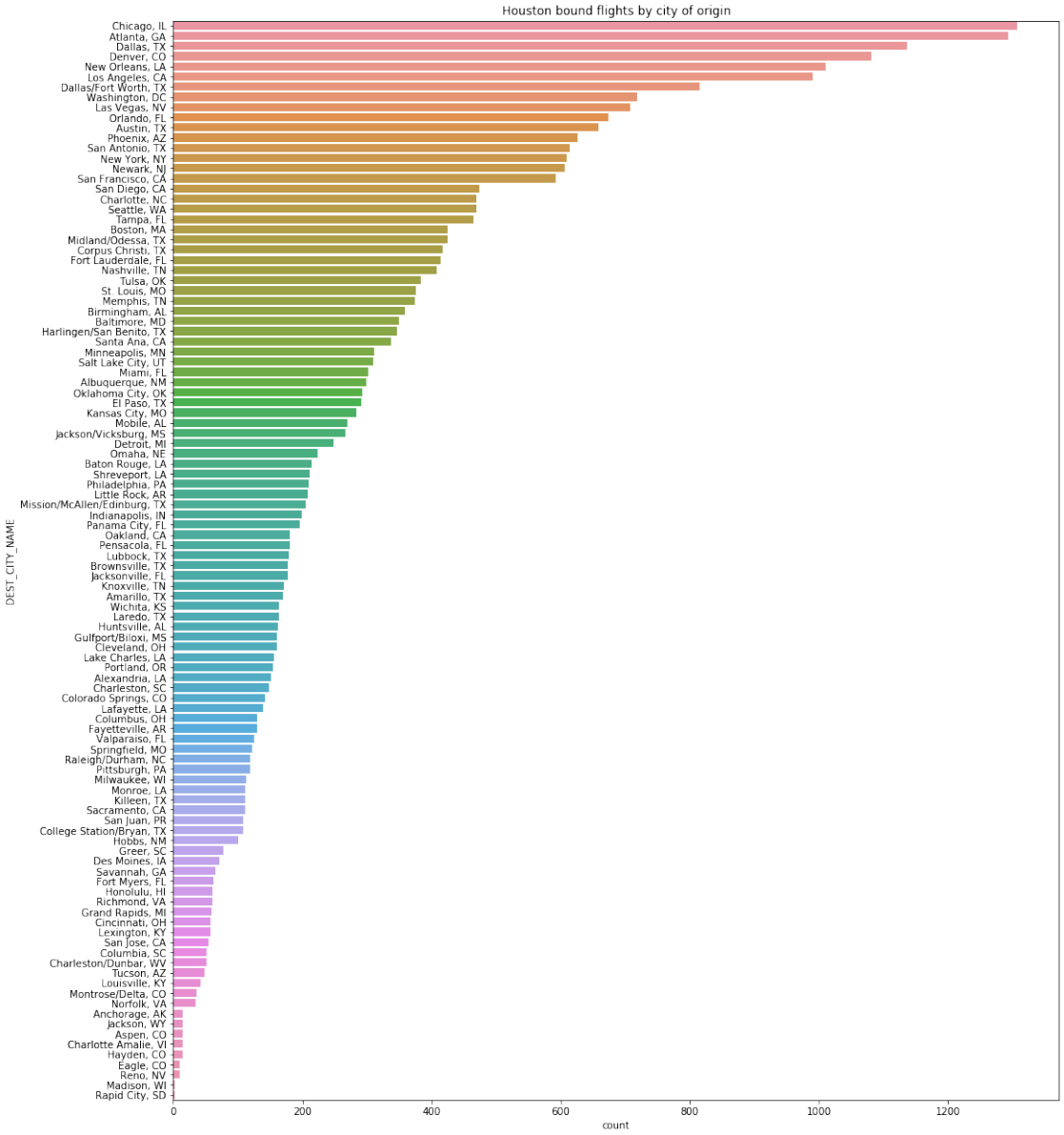


United and Southwest control about 60% of domestic flights into Houston. EV and OO trail WN but they can be considered as extension of United as they operate regional service on behalf of United.

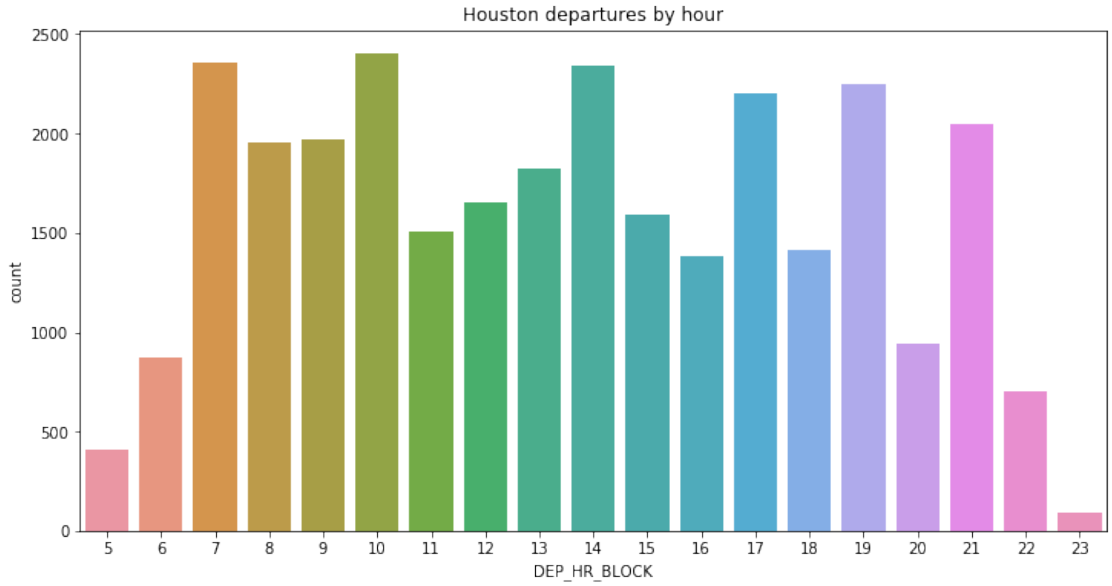
```
In [28]: plt.figure(figsize=(12,6))
         sns.countplot(data=houFlights,x='CARRIER_NAME')
         plt.xticks(rotation=30)
         plt.show()
```



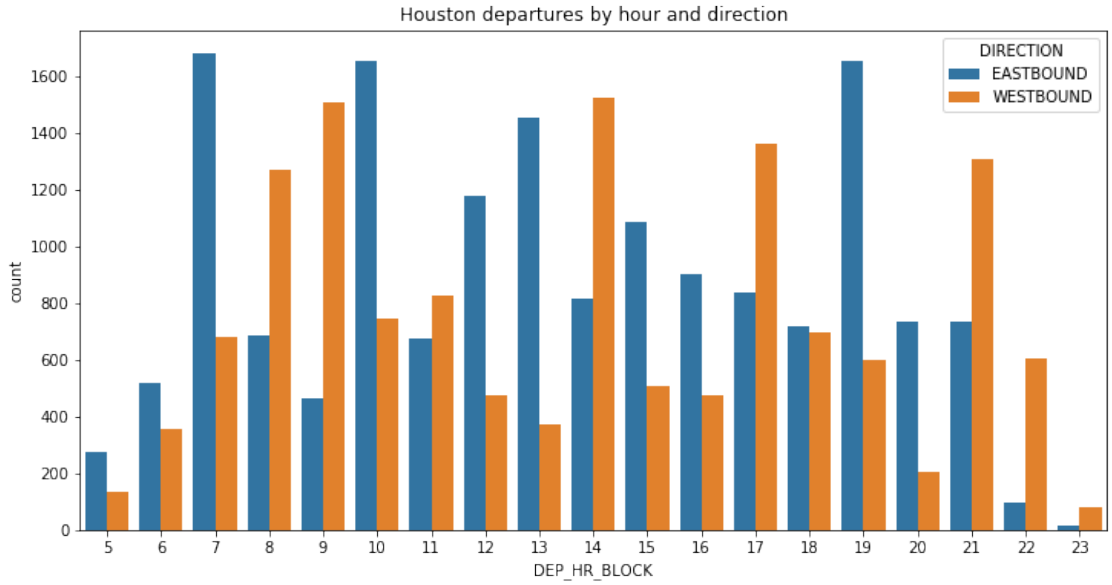

```
In [29]: plt.figure(figsize=(16,20))
         sns.countplot(data=houFlights[houFlights['DEST_CITY_NAME']!='Houston, TX'],y='DEST_CI
                       order = houFlights[houFlights['DEST_CITY_NAME']!='Houston, TX']['DEST_CI
         plt.title('Houston bound flights by city of origin')
         plt.show()
```




```
In [30]: plt.figure(figsize=(12,6))
         sns.countplot(data=houFlights[houFlights['ORIGIN_CITY_NAME']=='Houston, TX'],x='DEP_HI
         plt.title('Houston departures by hour')
         plt.show()
```



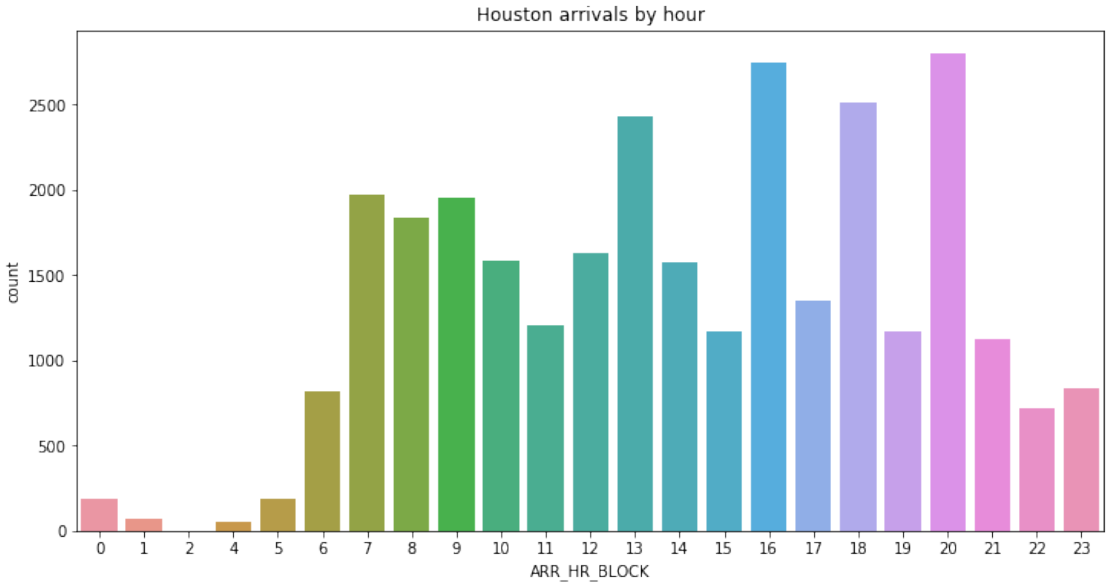

```
In [31]: plt.figure(figsize=(12,6))
         sns.countplot(data=houFlights[houFlights['ORIGIN_CITY_NAME']=='Houston, TX'],x='DEP_HR
         plt.title('Houston departures by hour and direction')
         plt.show()
```



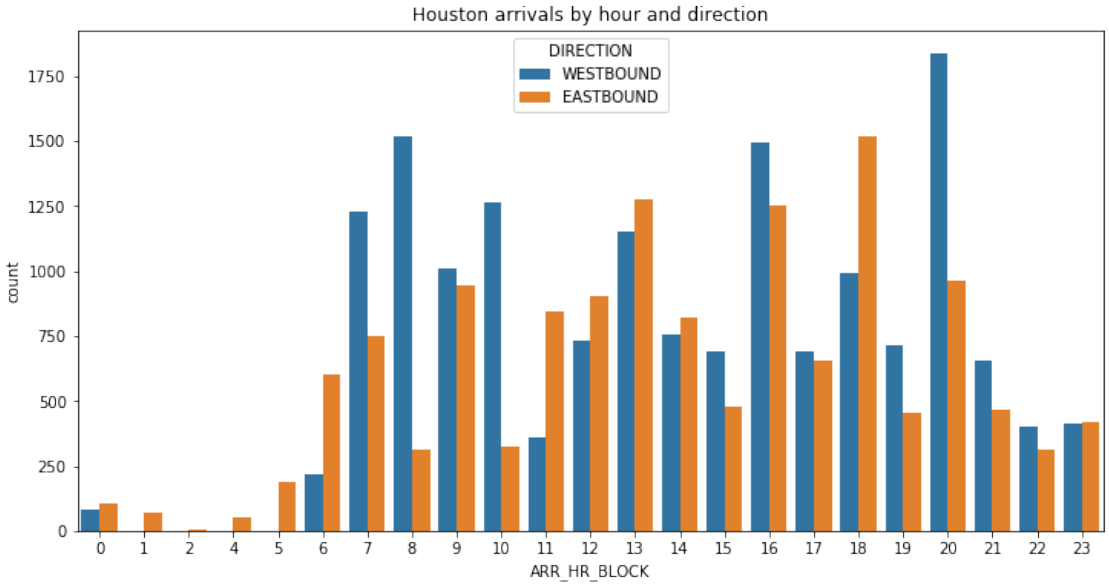
Outbound flights start at 5AM and peak between 7AM and 10AM. Most of the east coast bound flights are scheduled at 7AM and 7PM. There are very few east bound flights after 7PM. The ones that fly after 7PM could be hubs (Chicago, Atlanta etc) and nearby cities such as New Orleans.

Westbound departures start slow and peak at 9AM. The west bound flights before 9AM could be to nearby destinations such as Austin, Dallas and San Antonio. There is a high number of outbound flights at around 9PM and these could be California bound flights.

```
In [32]: plt.figure(figsize=(12,6))
         sns.countplot(data=houFlights[houFlights['DEST_CITY_NAME']=='Houston, TX'],x='ARR_HR_
         plt.title('Houston arrivals by hour')
         plt.show()
```




```
In [33]: plt.figure(figsize=(12,6))
         sns.countplot(data=houFlights[houFlights['DEST_CITY_NAME']=='Houston, TX'],x='ARR_HR_
         plt.title('Houston arrivals by hour and direction')
         plt.show()
```



Arrivals peak between 4PM and 8PM. There are many eastbound arrivans before 6AM and these could be red-eye arrivals from West Coast cities such as San Francisco, Los Angeles and Seattle. This could also include early morning flights from nearby Texas cities. These could be feeding the first major eastbound departure bank at 7AM. The highest number of arrivals from the east is at 8PM. This could eb the feed for the large westbound bank at 9PM and 10 PM.

```
In [34]: houFlights.iloc[0:10,1:22]
```

Out[34]:

	QUARTER	MONTH	DAY_OF_MONTH	DAY_OF_WEEK	FL_DATE	OP_CARRIER	TAIL_NUM	\
0	3	8	12	6	2017-08-12	B6	N520JB	
1	3	8	13	7	2017-08-13	B6	N579JB	
2	3	8	14	1	2017-08-14	B6	N559JB	
3	3	8	15	2	2017-08-15	B6	N526JB	
4	3	8	16	3	2017-08-16	B6	N648JB	
5	3	8	17	4	2017-08-17	B6	N547JB	
6	3	8	18	5	2017-08-18	B6	N629JB	
7	3	8	19	6	2017-08-19	B6	N827JB	
8	3	8	20	7	2017-08-20	B6	N510JB	
9	3	8	21	1	2017-08-21	B6	N568JB	

	OP_CARRIER_FL_NUM	ORIGIN_AIRPORT_ID	ORIGIN_CITY_MARKET_ID	...	\
0	581	12478	31703	...	
1	581	12478	31703	...	
2	581	12478	31703	...	
3	581	12478	31703	...	
4	581	12478	31703	...	
5	581	12478	31703	...	
6	581	12478	31703	...	
7	581	12478	31703	...	

```
8                581              12478                  31703      ...
9                581              12478                  31703      ...

  ORIGIN_CITY_NAME ORIGIN_STATE_ABR ORIGIN_STATE_NM ORIGIN_WAC  \
0     New York, NY               NY        New York         22
1     New York, NY               NY        New York         22
2     New York, NY               NY        New York         22
3     New York, NY               NY        New York         22
4     New York, NY               NY        New York         22
5     New York, NY               NY        New York         22
6     New York, NY               NY        New York         22
7     New York, NY               NY        New York         22
8     New York, NY               NY        New York         22
9     New York, NY               NY        New York         22

   DEST_AIRPORT_ID  DEST_CITY_MARKET_ID  DEST DEST_CITY_NAME DEST_STATE_ABR  \
0            12191                31453   HOU    Houston, TX             TX
1            12191                31453   HOU    Houston, TX             TX
2            12191                31453   HOU    Houston, TX             TX
3            12191                31453   HOU    Houston, TX             TX
4            12191                31453   HOU    Houston, TX             TX
5            12191                31453   HOU    Houston, TX             TX
6            12191                31453   HOU    Houston, TX             TX
7            12191                31453   HOU    Houston, TX             TX
8            12191                31453   HOU    Houston, TX             TX
9            12191                31453   HOU    Houston, TX             TX

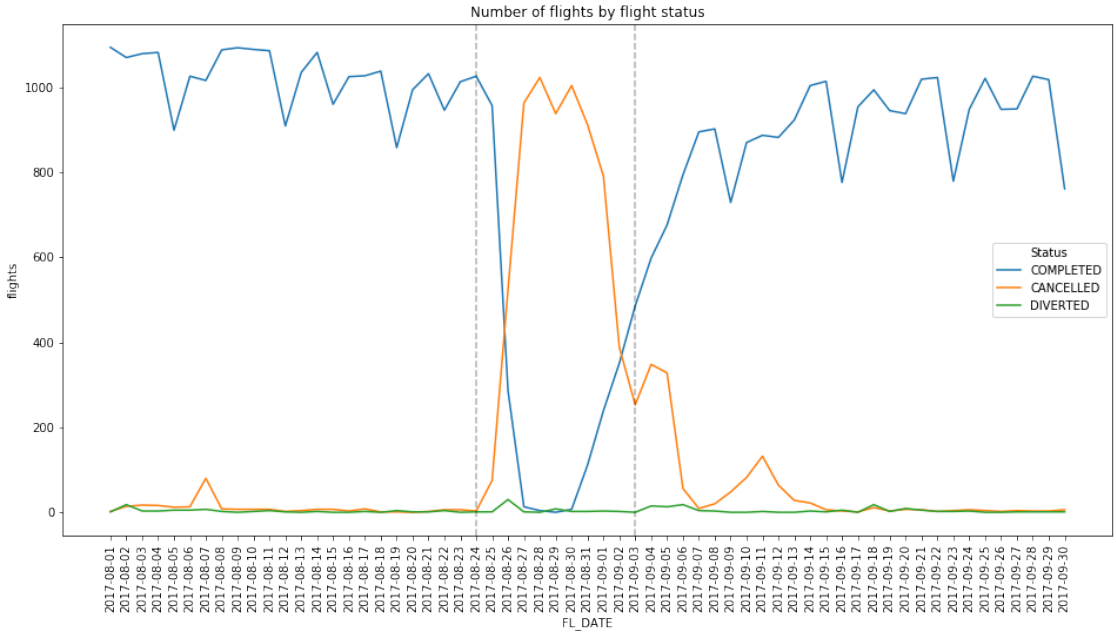
  DEST_STATE_NM
0         Texas
1         Texas
2         Texas
3         Texas
4         Texas
5         Texas
6         Texas
7         Texas
8         Texas
9         Texas

[10 rows x 21 columns]
```

0.2.2 Group by Date

```
In [35]: gByDateCCD = houFlights.groupby(['FL_DATE'],as_index=False).sum()[['FL_DATE','COMPLETI
         byDateStatusFlat = gByDateCCD.melt('FL_DATE',var_name ='Status',value_name='flights')
         plt.figure(figsize=(16,8))
         plt.xticks(rotation=90)
         ax = sns.lineplot(data=byDateStatusFlat,x='FL_DATE',y='flights',hue='Status')
```

```
plt.axvline('2017-08-24',linestyle='--',color='k',alpha=0.3)
plt.axvline('2017-09-03',linestyle='--',color='k',alpha=0.3)
plt.title('Number of flights by flight status')
plt.show()
```

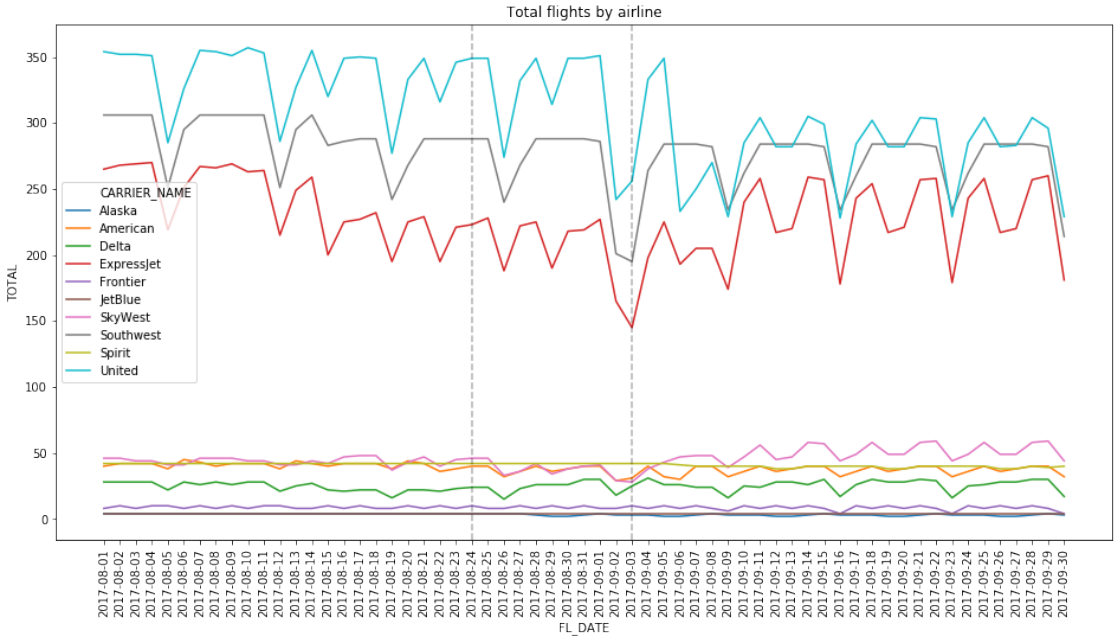


There were no completed flights between 8/29 and 8/30. There was a high number of diversions on 8/26

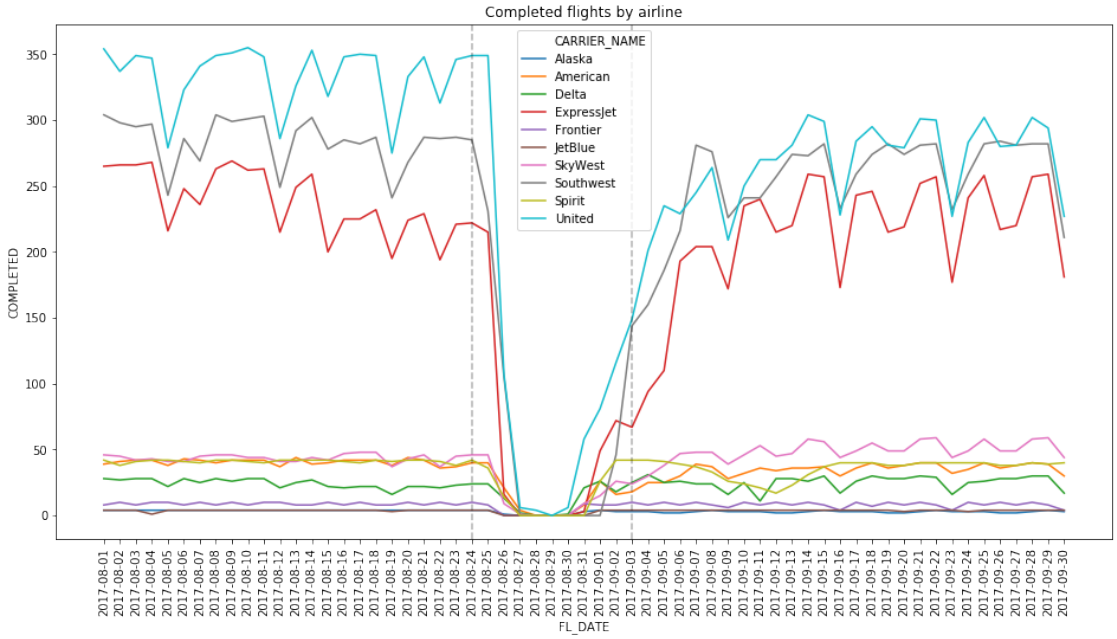
0.3 Group by Date and Airline

```
In [36]: #gByAirDate = houFlights.groupby(['FL_DATE','CARRIER_NAME'],as_index=False).count()[[
         gByAirDate = houFlights.groupby(['FL_DATE','CARRIER_NAME'],as_index=False).agg({
             'OP_CARRIER_FL_NUM':'count','CANCELLED':'sum','DIVERTED':'sum','COMPLETED':'sum'})
             'OP_CARRIER_FL_NUM':'TOTAL'})

In [37]: plt.figure(figsize=(16,8))
         plt.xticks(rotation=90)
         sns.lineplot(data=gByAirDate,x='FL_DATE',y='TOTAL',hue='CARRIER_NAME')
         plt.axvline('2017-08-24',linestyle='--',color='k',alpha=0.3)
         plt.axvline('2017-09-03',linestyle='--',color='k',alpha=0.3)
         plt.title('Total flights by airline')
         plt.show()
```

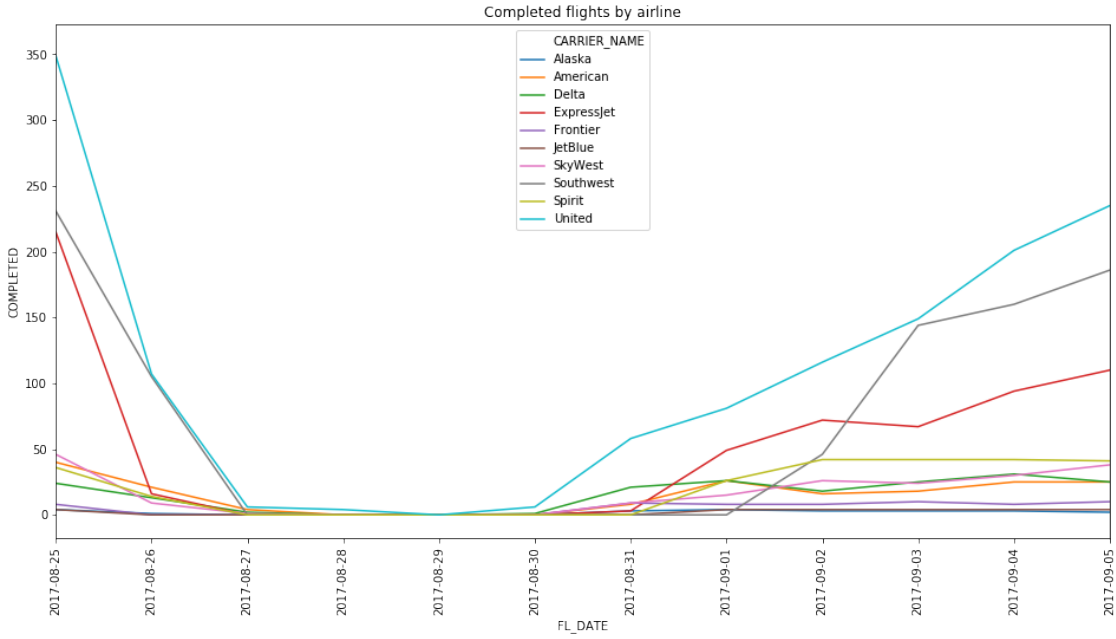


In [38]:
```
plt.figure(figsize=(16,8))
plt.xticks(rotation=90)
sns.lineplot(data=gByAirDate,x='FL_DATE',y='COMPLETED',hue='CARRIER_NAME')
plt.axvline('2017-08-24',linestyle='--',color='k',alpha=0.3)
plt.axvline('2017-09-03',linestyle='--',color='k',alpha=0.3)
plt.title('Completed flights by airline')
plt.show()
```

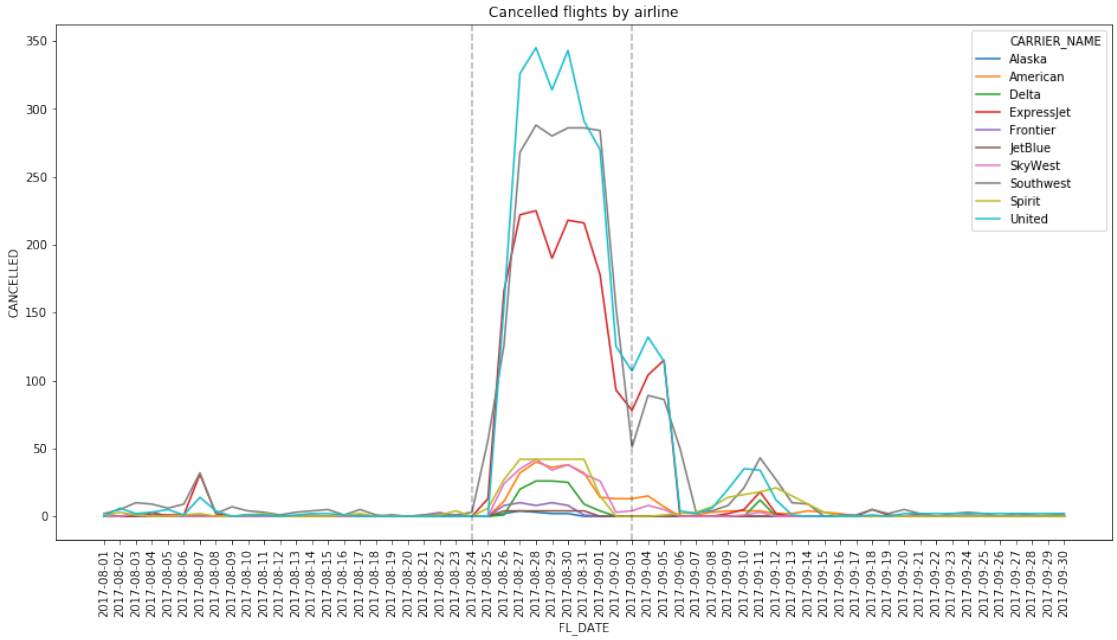


United and Southwest do not recover to the same level of operation 10 dasy after the hurricane. Spirit also shows an interesting pattern.

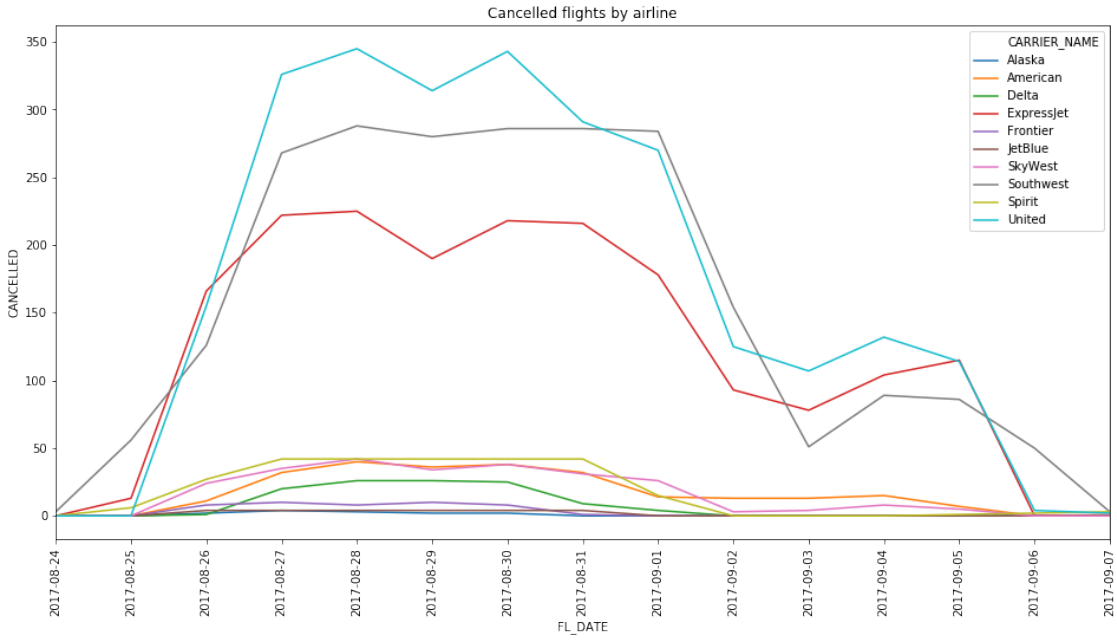
```
In [39]: plt.figure(figsize=(16,8))
         plt.xticks(rotation=90)
         sns.lineplot(data=gByAirDate,x='FL_DATE',y='COMPLETED',hue='CARRIER_NAME')
         plt.xlim('2017-08-25', '2017-09-05')
         #plt.axvline('2017-08-24',linestyle='--',color='k',alpha=0.3)
         #plt.axvline('2017-09-03',linestyle='--',color='k',alpha=0.3)
         plt.title('Completed flights by airline')
         plt.show()
```




```
In [40]: plt.figure(figsize=(16,8))
         plt.xticks(rotation=90)
         sns.lineplot(data=gByAirDate,x='FL_DATE',y='CANCELLED',hue='CARRIER_NAME')
         plt.axvline('2017-08-24',linestyle='--',color='k',alpha=0.3)
         plt.axvline('2017-09-03',linestyle='--',color='k',alpha=0.3)
         plt.title('Cancelled flights by airline')
         plt.show()
```

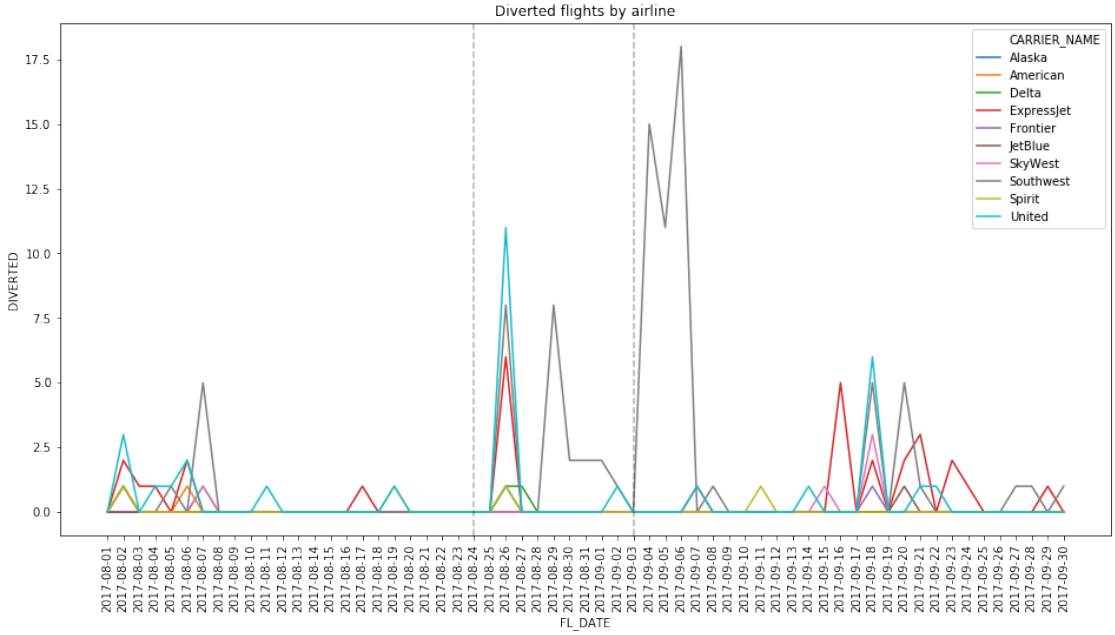



```
In [41]: plt.figure(figsize=(16,8))
         plt.xticks(rotation=90)
         sns.lineplot(data=gByAirDate,x='FL_DATE',y='CANCELLED',hue='CARRIER_NAME')
         plt.xlim('2017-08-24', '2017-09-07')
         plt.title('Cancelled flights by airline')
         plt.show()
```



0.3.1 Diversions

```
In [42]: #Counting only Inbpound Diversions
         divByDateAndAirline = houFlights[houFlights['INBOUND']==1].groupby(['FL_DATE','CARRIE
             'OP_CARRIER_FL_NUM':'count','DIVERTED':'sum'}).rename(columns={
             'OP_CARRIER_FL_NUM':'TOTAL'})
         plt.figure(figsize=(16,8))
         plt.xticks(rotation=90)
         sns.lineplot(data=divByDateAndAirline,x='FL_DATE',y='DIVERTED',hue='CARRIER_NAME')
         plt.axvline('2017-08-24',linestyle='--',color='k',alpha=0.3)
         plt.axvline('2017-09-03',linestyle='--',color='k',alpha=0.3)
         plt.title('Diverted flights by airline')
         plt.show()
```



Southwest has a large number of diversions after the hurricane. There are atleast 10 daily diversions each day till 9/7

```
In [43]: houInboundDiversions = houFlights[(houFlights['INBOUND']==1)&(houFlights['DIVERTED']==
         houInboundDiversions = pd.merge(houInboundDiversions,airports[['Code3','Lat','Lon']],
         houInboundDiversions.rename(columns={'Lat':'Lat_Div','Lon':'Lon_Div'}, inplace=True)
         houInboundDiversions.drop(['Code3'],axis=1,inplace=True)

In [44]: gByDiv = houInboundDiversions.groupby(['DIV1_AIRPORT','Lat_Div','Lon_Div']).size().res
         gByDiv.rename(columns={0:'Count'}, inplace=True)
         #gByDiv.sort_values(by='Count',ascending=False)

In [45]: cities = []
         scale = 0.5
```

```
colors = ['rgb(239,243,255)','rgb(189,215,231)','rgb(107,174,214)','rgb(33,113,181)']

for i in range(len(gByDiv)):
    city = dict(
        type = 'scattergeo',
        locationmode = 'USA-states',
        lon = gByDiv['Lon_Div'],
        lat = gByDiv['Lat_Div'],
        #text = str(gByDiv['DIV1_AIRPORT'])+str(gByDiv['Count']),
        text = gByDiv['DIV1_AIRPORT'],
        marker = dict(
            size = gByDiv['Count']/scale,
            line = dict(width=0.5, color='rgb(40,40,40)'),
            sizemode = 'area'
        ))
    cities.append(city)

layout = dict(geo={'scope':'usa'},
                title='Count of flights diverted to',
             showlegend=False)

fig = dict(data = cities ,layout=layout)
iplot(fig)
```

There are some diversions to locations such as OAK, LAX, DTW, ORD and Florida that are too far from Houston to be considered last minute diversions. Let us plot the map of their origin and diverted airport to understand what is happening here.

In [46]:
```
ldDivLoc = ['OAK','LAX','SAN','LAS','PHX','DTW','ORD','TPA','FLL','JAX']
longHouInboundDiversions = houInboundDiversions[houInboundDiversions['DIV1_AIRPORT'].
```

In [47]:
```
airportsMap = [ dict(
        type = 'scattergeo',
        locationmode = 'USA-states',
        lon = longHouInboundDiversions['Lon_Ori'],
        lat = longHouInboundDiversions['Lat_Ori'],
        hoverinfo = 'text',
        text = longHouInboundDiversions['ORIGIN'],
        mode = 'markers',
        marker = dict(
            size=2,
            color='rgb(255, 0, 0)',
            line = dict(
                width=3,
                color='rgba(68, 68, 68, 0)'
            )
        ))]
```

```
flight_paths = []
for i in range( len(longHouInboundDiversions) ):
    flight_paths.append(
        dict(
            type = 'scattergeo',
            locationmode = 'USA-states',
            lon = [ longHouInboundDiversions['Lon_Ori'][i], longHouInboundDiversions[
            lat = [ longHouInboundDiversions['Lat_Ori'][i], longHouInboundDiversions[
            mode = 'lines',
            line = dict(
                width = 1,
                color = 'red',
            ),
            #opacity = (float(gByOriDest['Count'][i])/float(gByOriDest['Count'].max()
        )
    )

layout = dict(geo={'scope':'usa'},
              title='Diverted flights (long distance)',
              showlegend=False)

fig = dict(data = flight_paths + airportsMap,layout=layout)
iplot(fig)
```

In [48]:
```
longHouInboundDiversions[['ORIGIN','DEST','DIV1_AIRPORT','OP_CARRIER','OP_CARRIER_FL_
```

Out[48]:

	ORIGIN	DEST	DIV1_AIRPORT	OP_CARRIER	OP_CARRIER_FL_NUM
0	ATL	HOU	PHX	WN	1937
1	ATL	HOU	PHX	WN	1937
2	ATL	HOU	PHX	WN	1937
3	ATL	HOU	PHX	WN	1937
4	TPA	HOU	SAN	WN	1549
5	ABQ	HOU	TPA	WN	4786
6	ABQ	HOU	TPA	WN	1802
7	BWI	HOU	LAX	WN	1662
8	BWI	HOU	LAS	WN	4496
9	BWI	HOU	LAX	WN	1662
10	BWI	HOU	OAK	WN	1518
11	BWI	HOU	LAX	WN	1662
12	MCO	HOU	OAK	WN	2007
13	OKC	HOU	LAX	WN	5147
14	RDU	HOU	LAS	WN	1066
15	RDU	HOU	LAS	WN	1066
16	RDU	HOU	LAS	WN	1066
17	SAN	HOU	JAX	WN	4479
18	SAT	HOU	FLL	WN	18
19	HNL	IAH	LAX	UA	252

```
20    EWR  IAH          ORD          UA                1261
21    DTW  IAH          DTW          NK                 939
```

The above map confirms my suspicion that these flights are not last minute diversions. Lets look closer at these flights: - 4 flights from Atlanta to Houston Hobby were diverted to Albuquerqe - A Tampa to Hobby flight was diverted San Diego - 5 flights from baltimore to Hobby were diverted to Las vegas and Los Angeles - The flight numbers are repeating - Most of these routes belong to Southwest As no airline will carry enough fuel to divert to a destination too far away from its destination airport, I am assuming that Southwest diverted their flights to the next airport on its route, skipping Houston Hobby.

```
In [49]: shortHouInboundDiversions = houInboundDiversions[~houInboundDiversions['DIV1_AIRPORT']
```

```
In [50]: airportsMap = [ dict(
                type = 'scattergeo',
                locationmode = 'USA-states',
                lon = shortHouInboundDiversions['Lon_Ori'],
                lat = shortHouInboundDiversions['Lat_Ori'],
                hoverinfo = 'text',
                text = shortHouInboundDiversions['ORIGIN'],
                mode = 'markers',
                marker = dict(
                    size=2,
                    color='rgb(255, 0, 0)',
                    line = dict(
                        width=3,
                        color='rgba(68, 68, 68, 0)'
                    )
                ))]


        flight_paths = []
        for i in range( len(shortHouInboundDiversions) ):
            flight_paths.append(
                dict(
                    type = 'scattergeo',
                    locationmode = 'USA-states',
                    lon = [ shortHouInboundDiversions['Lon_Ori'][i], shortHouInboundDiversions
                    lat = [ shortHouInboundDiversions['Lat_Ori'][i], shortHouInboundDiversions
                    mode = 'lines',
                    line = dict(
                        width = 1,
                        color = 'red',
                    ),
                    #opacity = (float(gByOriDest['Count'][i])/float(gByOriDest['Count'].max()),
                )
            )
```

```
layout = dict(geo={'scope':'usa'},
              title='Diversions (excluding long distance Southwest hops)',
              showlegend=False)

fig = dict(data = flight_paths + airportsMap,layout=layout)
iplot(fig)
```

The above map shows that most eastbound flights were diverted to Austin, San Antonio and South Padre. Most westbound flights were diverted to Dallas and New Orleans

0.4 Rain Data

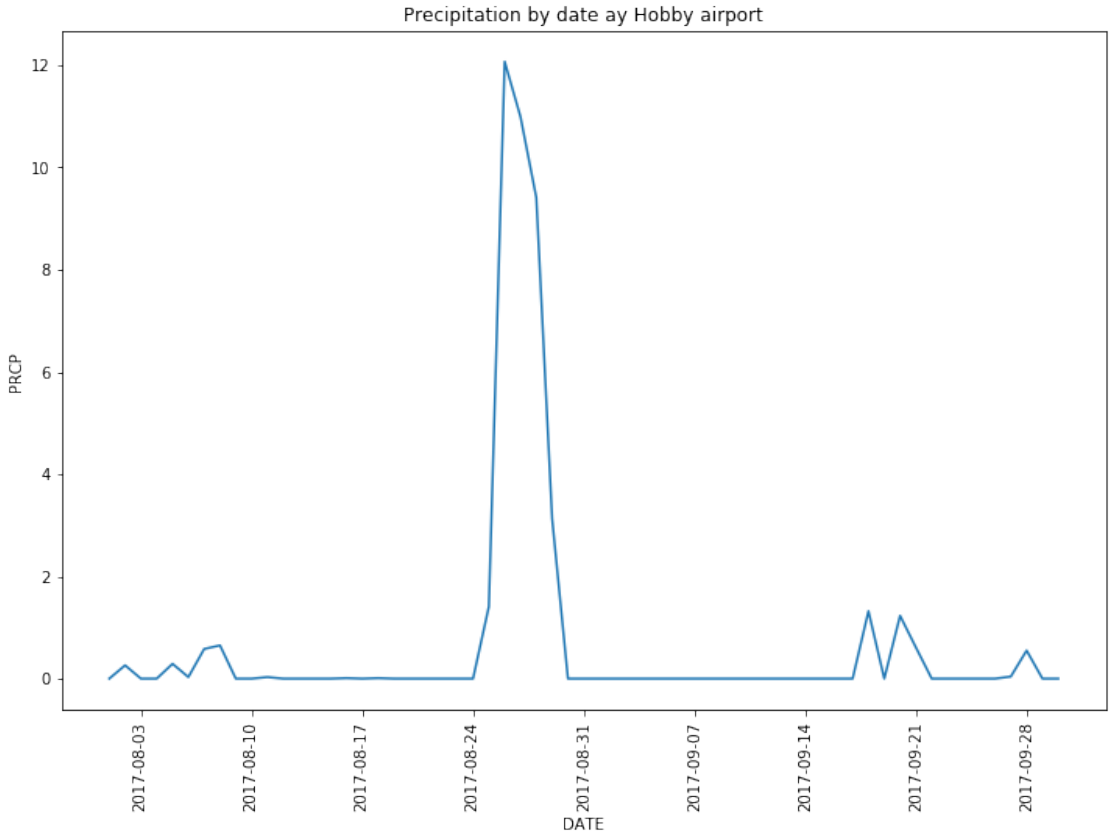
```
In [51]: weather_hou = pd.read_csv('Weather_HOU.csv')
         weather_hou.head()
```

Out[51]:

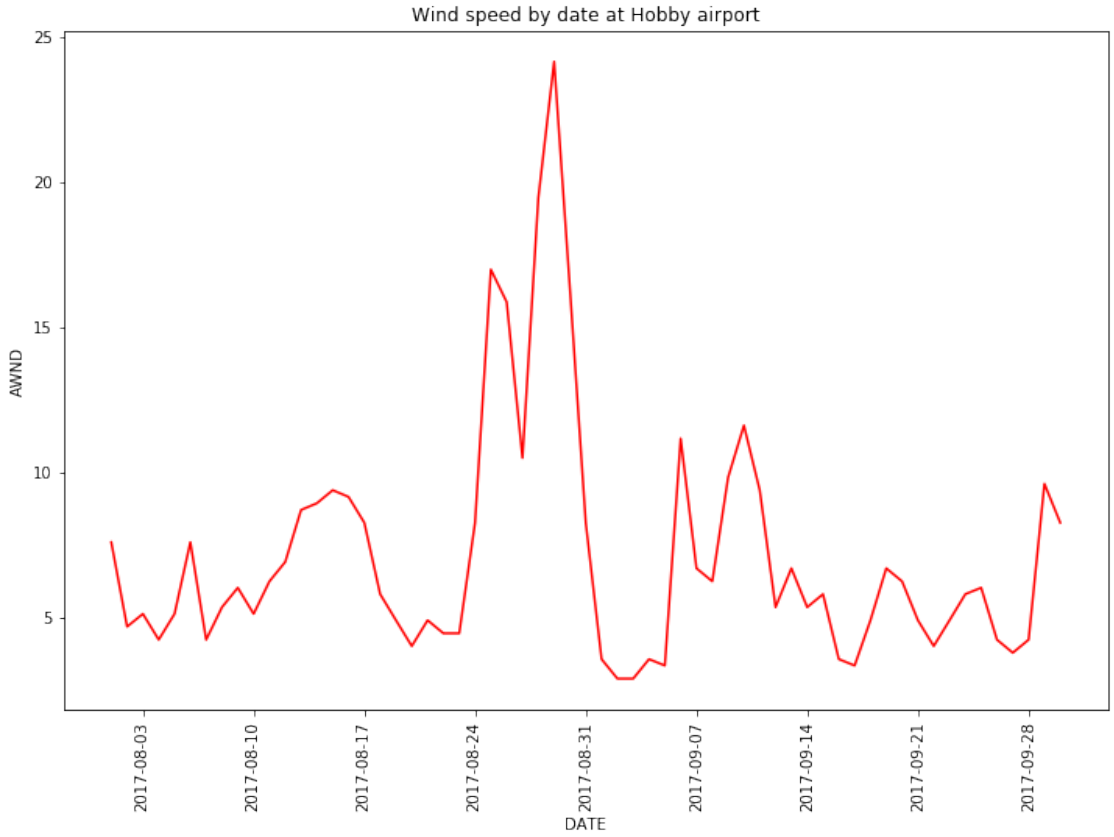
	STATION	NAME	DATE	AWND	PRCP	TAVG	TMAX	TMIN
0	USW00012918	HOUSTON WILLIAM P HOBBY AIRPORT, TX US	8/1/2017	7.61	0.00	87	95	80
1	USW00012918	HOUSTON WILLIAM P HOBBY AIRPORT, TX US	8/2/2017	4.70	0.26	83	91	77
2	USW00012918	HOUSTON WILLIAM P HOBBY AIRPORT, TX US	8/3/2017	5.14	0.00	82	94	77
3	USW00012918	HOUSTON WILLIAM P HOBBY AIRPORT, TX US	8/4/2017	4.25	0.00	85	95	77
4	USW00012918	HOUSTON WILLIAM P HOBBY AIRPORT, TX US	8/5/2017	5.14	0.29	84	95	77

```
In [52]: weather_hou.drop(['STATION','NAME'],axis=1,inplace=True)
         weather_hou['DATE'] = pd.to_datetime(weather_hou['DATE'],format='%m/%d/%Y')

In [53]: plt.figure(figsize=(12,8))
         plt.xticks(rotation=90)
         sns.lineplot(data=weather_hou,x='DATE',y='PRCP')
         plt.title('Precipitation by date ay Hobby airport')
         plt.show()
```

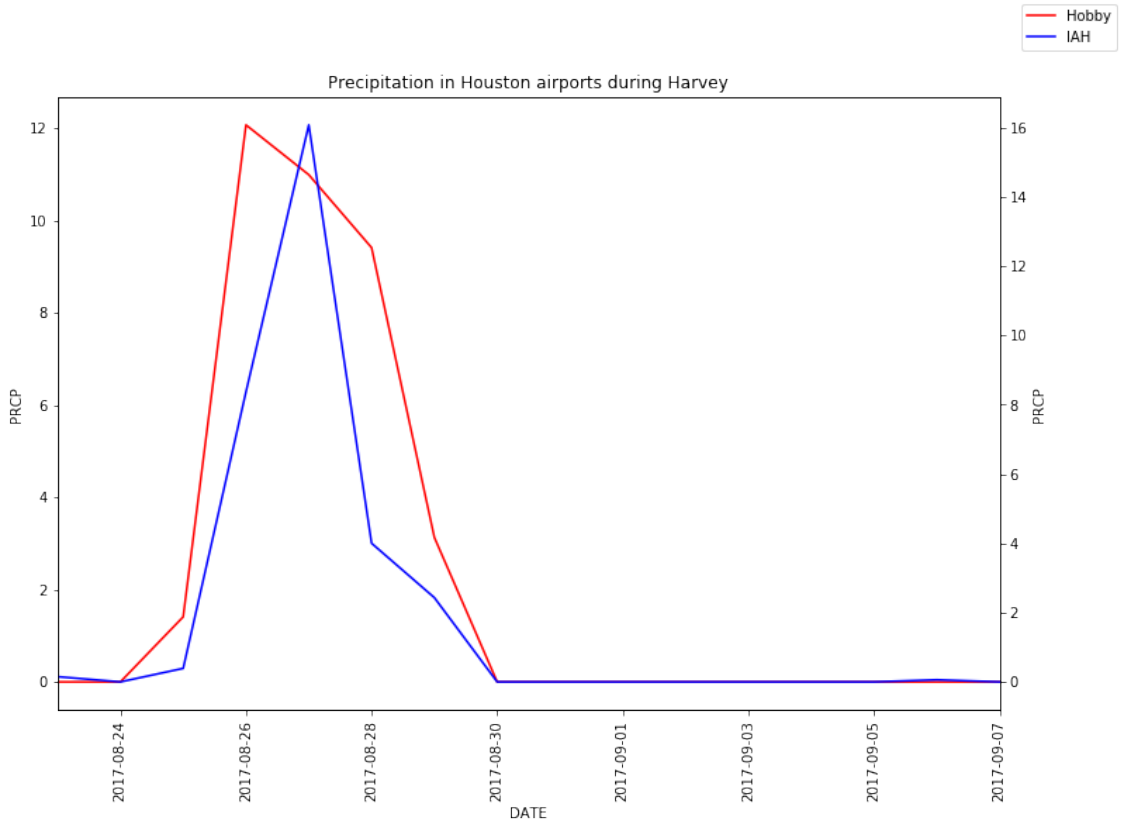


In [54]:
```
plt.figure(figsize=(12,8))
plt.xticks(rotation=90)
sns.lineplot(data=weather_hou,x='DATE',y='AWND',color='red')
#sns.lineplot(data=weather_hou,x='DATE',y='PRCP')
plt.title('Wind speed by date at Hobby airport')
plt.show()
```




```
In [55]: weather_iah = pd.read_csv('weather_iah.csv')
         weather_iah.drop(['STATION','NAME','LATITUDE','LONGITUDE','ELEVATION'],axis=1,inplace=
         weather_iah['DATE'] = pd.to_datetime(weather_iah['DATE'],format='%Y-%m-%d')

In [56]: weather_iah = weather_iah[weather_iah['DATE']<'2017-10-01']
         fig = plt.figure(figsize=(12,8))
         plt.xticks(rotation=90)
         ax = sns.lineplot(data=weather_hou,x='DATE',y='PRCP',color='red',legend=False)
         ax2 = ax.twinx()
         sns.lineplot(data=weather_iah,x='DATE',y='PRCP',color='blue',legend=False,ax=ax2)
         fig.legend(['Hobby','IAH'])
         plt.xlim('2017-08-23', '2017-09-07')
         plt.title('Precipitation in Houston airports during Harvey')
         plt.show()
```



HOU recieved more rain than IAH. Also, Hobby received its maximim precipitation on 8/25th and but it continued to receive more than 10 inches of rain till 8/29. IAH recieved more than 4 inches of rain on one day only. So IAH was quik to recover than HOU. This explains the large number of cancellations and diversions from airlines based in HOU after the storm (Southwest and JetBlue)

0.5 Flights in the storm

0.5.1 United

```
In [57]: houFlights[(houFlights['DATE'] == '2017-08-26')&(houFlights['STATUS']=='Completed')&(
```

```
Out[57]: 1    55
         0    52
         Name: INBOUND, dtype: int64
```

```
In [58]: houFlights[(houFlights['DATE'] == '2017-08-27')&(houFlights['STATUS']=='Completed')&(
```

```
Out[58]:       OP_CARRIER TAIL_NUM  OP_CARRIER_FL_NUM  ORIGIN_AIRPORT_ID  \
         16161         UA   N834UA                 75              12266
         19465         UA   N74856               1897              12266
         26768         UA   N56859                438              12266
         43171         UA   N13113                762              12264
```

```
52022         UA   N806UA                527             12266
52023         UA   N847UA                638             12266

       ORIGIN_CITY_MARKET_ID ORIGIN ORIGIN_CITY_NAME ORIGIN_STATE_ABR  \
16161                 31453    IAH      Houston, TX               TX
19465                 31453    IAH      Houston, TX               TX
26768                 31453    IAH      Houston, TX               TX
43171                 30852    IAD   Washington, DC               VA
52022                 31453    IAH      Houston, TX               TX
52023                 31453    IAH      Houston, TX               TX

      ORIGIN_STATE_NM  ORIGIN_WAC  DEST_AIRPORT_ID  DEST_CITY_MARKET_ID DEST  \
16161           Texas          74            11292                30325  DEN
19465           Texas          74            12892                32575  LAX
26768           Texas          74            14747                30559  SEA
43171        Virginia          38            12266                31453  IAH
52022           Texas          74            13930                30977  ORD
52023           Texas          74            13930                30977  ORD

        DEST_CITY_NAME
16161       Denver, CO
19465  Los Angeles, CA
26768      Seattle, WA
43171      Houston, TX
52022      Chicago, IL
52023      Chicago, IL
```

Most flights on 27th are outbound flights to hubs to fly out passengers stranded at IAH.

```
In [59]: houFlights[(houFlights['DATE'] == '2017-08-28')&(houFlights['STATUS']=='Completed')&(
```

```
Out[59]:       OP_CARRIER TAIL_NUM  OP_CARRIER_FL_NUM  ORIGIN_AIRPORT_ID  \
15929         UA   N77525                 75             12266
15932         UA   N77258                825             12266
29350         UA   N37420               1554             12266
51515         UA   N63890                321             12266

       ORIGIN_CITY_MARKET_ID ORIGIN ORIGIN_CITY_NAME ORIGIN_STATE_ABR  \
15929                 31453    IAH      Houston, TX               TX
15932                 31453    IAH      Houston, TX               TX
29350                 31453    IAH      Houston, TX               TX
51515                 31453    IAH      Houston, TX               TX

      ORIGIN_STATE_NM  ORIGIN_WAC  DEST_AIRPORT_ID  DEST_CITY_MARKET_ID DEST  \
15929           Texas          74            11292                30325  DEN
15932           Texas          74            11292                30325  DEN
29350           Texas          74            11298                30194  DFW
51515           Texas          74            12264                30852  IAD
```

```
                DEST_CITY_NAME
15929               Denver, CO
15932               Denver, CO
29350  Dallas/Fort Worth, TX
51515           Washington, DC
```

We see a similar pattern on 28th, outbound flights to United hubs. There were no operations on 29th.

```
In [60]: houFlights[(houFlights['DATE'] == '2017-08-30')&(houFlights['STATUS']=='Completed')&(
```

```
Out[60]:       OP_CARRIER TAIL_NUM  OP_CARRIER_FL_NUM  ORIGIN_AIRPORT_ID  \
15912         UA   N78509                437              12266
42507         UA   N27901               1615              14771
43342         UA   N68822                341              11618
43956         UA   N79402               1290              13930
51769         UA   N33289               1074              12266
52953         UA   N79402               1867              12266

       ORIGIN_CITY_MARKET_ID ORIGIN   ORIGIN_CITY_NAME ORIGIN_STATE_ABR  \
15912                  31453    IAH        Houston, TX               TX
42507                  32457    SFO  San Francisco, CA               CA
43342                  31703    EWR         Newark, NJ               NJ
43956                  30977    ORD        Chicago, IL               IL
51769                  31453    IAH        Houston, TX               TX
52953                  31453    IAH        Houston, TX               TX

      ORIGIN_STATE_NM  ORIGIN_WAC  DEST_AIRPORT_ID  DEST_CITY_MARKET_ID DEST  \
15912           Texas          74            11292                30325  DEN
42507      California          91            12266                31453  IAH
43342      New Jersey          21            12266                31453  IAH
43956        Illinois          41            12266                31453  IAH
51769           Texas          74            13930                30977  ORD
52953           Texas          74            11618                31703  EWR

      DEST_CITY_NAME
15912     Denver, CO
42507    Houston, TX
43342    Houston, TX
43956    Houston, TX
51769    Chicago, IL
52953     Newark, NJ
```

This is where the recovery really started. On 30th, United flew flights to its hubs. We do not have enough data but this looks like cre-only flights to get starnded crew out and get new crew in to operate the flights based in Houston.

```
In [61]: houFlights[(houFlights['DATE'] == '2017-08-31')&(houFlights['STATUS']=='Completed')&(
```

```
Out[61]: 1    31
         0    27
         Name: INBOUND, dtype: int64

In [62]: houFlights[(houFlights['DATE'] == '2017-08-31')&(houFlights['STATUS']=='Completed')&(
```

Out[62]:

	OP_CARRIER	TAIL_NUM	OP_CARRIER_FL_NUM	ORIGIN_AIRPORT_ID	\
15903	UA	N24212	437	12266	
15905	UA	N78524	825	12266	
15907	UA	N87512	1146	12266	
15908	UA	N68843	1672	12266	
15909	UA	N33292	1874	12266	
18471	UA	N73256	2091	12266	
19166	UA	N79402	1117	12266	
19170	UA	N66841	1236	12266	
19171	UA	N66814	1777	12266	
19173	UA	N68823	1813	12266	
19175	UA	N62889	1964	12266	
23152	UA	N12238	1131	12266	
30387	UA	N26210	44	11292	
30388	UA	N24212	545	11292	
30390	UA	N68843	1114	11292	
30392	UA	N68805	1184	11292	
30393	UA	N78524	1819	11292	
30394	UA	N17244	1828	11292	
30395	UA	N87512	1874	11292	
30396	UA	N68843	1975	11292	
36310	UA	N66814	1125	12892	
36311	UA	N62889	1241	12892	
36312	UA	N36476	1407	12892	
36316	UA	N77867	1963	12892	
36317	UA	N66841	1981	12892	
36318	UA	N57870	1984	12892	
36319	UA	N72405	2027	12892	
42494	UA	N17245	912	14771	
42498	UA	N75858	1958	14771	
42499	UA	N53442	2058	14771	
43072	UA	N38417	249	12264	
43073	UA	N29124	484	12264	
43335	UA	N12238	663	11618	
43336	UA	N667UA	687	11618	
43337	UA	N79402	1161	11618	
43338	UA	N77537	1261	11618	
43339	UA	N68823	1534	11618	
43340	UA	N676UA	1810	11618	
43941	UA	N654UA	374	13930	
43942	UA	N643UA	589	13930	
43945	UA	N73406	1128	13930	

43948	UA	N66803	1875	13930
43949	UA	N37408	2043	13930
51503	UA	N29124	321	12266
51504	UA	N68822	589	12266
51756	UA	N643UA	462	12266
51757	UA	N37408	527	12266
51759	UA	N36476	1074	12266
51761	UA	N66803	1256	12266
51764	UA	N656UA	1967	12266
52939	UA	N668UA	665	12266
52941	UA	N72405	936	12266
53543	UA	N68805	385	12266
53548	UA	N77867	1541	12266
53549	UA	N53442	1788	12266
53550	UA	N73406	1844	12266
53551	UA	N75858	1973	12266
53552	UA	N64809	2382	12266

	ORIGIN_CITY_MARKET_ID	ORIGIN	ORIGIN_CITY_NAME	ORIGIN_STATE_ABR	\
15903	31453	IAH	Houston, TX	TX	
15905	31453	IAH	Houston, TX	TX	
15907	31453	IAH	Houston, TX	TX	
15908	31453	IAH	Houston, TX	TX	
15909	31453	IAH	Houston, TX	TX	
18471	31453	IAH	Houston, TX	TX	
19166	31453	IAH	Houston, TX	TX	
19170	31453	IAH	Houston, TX	TX	
19171	31453	IAH	Houston, TX	TX	
19173	31453	IAH	Houston, TX	TX	
19175	31453	IAH	Houston, TX	TX	
23152	31453	IAH	Houston, TX	TX	
30387	30325	DEN	Denver, CO	CO	
30388	30325	DEN	Denver, CO	CO	
30390	30325	DEN	Denver, CO	CO	
30392	30325	DEN	Denver, CO	CO	
30393	30325	DEN	Denver, CO	CO	
30394	30325	DEN	Denver, CO	CO	
30395	30325	DEN	Denver, CO	CO	
30396	30325	DEN	Denver, CO	CO	
36310	32575	LAX	Los Angeles, CA	CA	
36311	32575	LAX	Los Angeles, CA	CA	
36312	32575	LAX	Los Angeles, CA	CA	
36316	32575	LAX	Los Angeles, CA	CA	
36317	32575	LAX	Los Angeles, CA	CA	
36318	32575	LAX	Los Angeles, CA	CA	
36319	32575	LAX	Los Angeles, CA	CA	
42494	32457	SFO	San Francisco, CA	CA	
42498	32457	SFO	San Francisco, CA	CA	

42499	32457	SFO	San Francisco, CA	CA	
43072	30852	IAD	Washington, DC	VA	
43073	30852	IAD	Washington, DC	VA	
43335	31703	EWR	Newark, NJ	NJ	
43336	31703	EWR	Newark, NJ	NJ	
43337	31703	EWR	Newark, NJ	NJ	
43338	31703	EWR	Newark, NJ	NJ	
43339	31703	EWR	Newark, NJ	NJ	
43340	31703	EWR	Newark, NJ	NJ	
43941	30977	ORD	Chicago, IL	IL	
43942	30977	ORD	Chicago, IL	IL	
43945	30977	ORD	Chicago, IL	IL	
43948	30977	ORD	Chicago, IL	IL	
43949	30977	ORD	Chicago, IL	IL	
51503	31453	IAH	Houston, TX	TX	
51504	31453	IAH	Houston, TX	TX	
51756	31453	IAH	Houston, TX	TX	
51757	31453	IAH	Houston, TX	TX	
51759	31453	IAH	Houston, TX	TX	
51761	31453	IAH	Houston, TX	TX	
51764	31453	IAH	Houston, TX	TX	
52939	31453	IAH	Houston, TX	TX	
52941	31453	IAH	Houston, TX	TX	
53543	31453	IAH	Houston, TX	TX	
53548	31453	IAH	Houston, TX	TX	
53549	31453	IAH	Houston, TX	TX	
53550	31453	IAH	Houston, TX	TX	
53551	31453	IAH	Houston, TX	TX	
53552	31453	IAH	Houston, TX	TX	

	ORIGIN_STATE_NM	ORIGIN_WAC	DEST_AIRPORT_ID	DEST_CITY_MARKET_ID	DEST	\
15903	Texas	74	11292	30325	DEN	
15905	Texas	74	11292	30325	DEN	
15907	Texas	74	11292	30325	DEN	
15908	Texas	74	11292	30325	DEN	
15909	Texas	74	11292	30325	DEN	
18471	Texas	74	12889	32211	LAS	
19166	Texas	74	12892	32575	LAX	
19170	Texas	74	12892	32575	LAX	
19171	Texas	74	12892	32575	LAX	
19173	Texas	74	12892	32575	LAX	
19175	Texas	74	12892	32575	LAX	
23152	Texas	74	13495	33495	MSY	
30387	Colorado	82	12266	31453	IAH	
30388	Colorado	82	12266	31453	IAH	
30390	Colorado	82	12266	31453	IAH	
30392	Colorado	82	12266	31453	IAH	
30393	Colorado	82	12266	31453	IAH	

30394	Colorado	82	12266	31453	IAH
30395	Colorado	82	12266	31453	IAH
30396	Colorado	82	12266	31453	IAH
36310	California	91	12266	31453	IAH
36311	California	91	12266	31453	IAH
36312	California	91	12266	31453	IAH
36316	California	91	12266	31453	IAH
36317	California	91	12266	31453	IAH
36318	California	91	12266	31453	IAH
36319	California	91	12266	31453	IAH
42494	California	91	12266	31453	IAH
42498	California	91	12266	31453	IAH
42499	California	91	12266	31453	IAH
43072	Virginia	38	12266	31453	IAH
43073	Virginia	38	12266	31453	IAH
43335	New Jersey	21	12266	31453	IAH
43336	New Jersey	21	12266	31453	IAH
43337	New Jersey	21	12266	31453	IAH
43338	New Jersey	21	12266	31453	IAH
43339	New Jersey	21	12266	31453	IAH
43340	New Jersey	21	12266	31453	IAH
43941	Illinois	41	12266	31453	IAH
43942	Illinois	41	12266	31453	IAH
43945	Illinois	41	12266	31453	IAH
43948	Illinois	41	12266	31453	IAH
43949	Illinois	41	12266	31453	IAH
51503	Texas	74	12264	30852	IAD
51504	Texas	74	12264	30852	IAD
51756	Texas	74	13930	30977	ORD
51757	Texas	74	13930	30977	ORD
51759	Texas	74	13930	30977	ORD
51761	Texas	74	13930	30977	ORD
51764	Texas	74	13930	30977	ORD
52939	Texas	74	11618	31703	EWR
52941	Texas	74	11618	31703	EWR
53543	Texas	74	14771	32457	SFO
53548	Texas	74	14771	32457	SFO
53549	Texas	74	14771	32457	SFO
53550	Texas	74	14771	32457	SFO
53551	Texas	74	14771	32457	SFO
53552	Texas	74	14771	32457	SFO

	DEST_CITY_NAME
15903	Denver, CO
15905	Denver, CO
15907	Denver, CO
15908	Denver, CO
15909	Denver, CO

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18471      Las Vegas, NV
19166    Los Angeles, CA
19170    Los Angeles, CA
19171    Los Angeles, CA
19173    Los Angeles, CA
19175    Los Angeles, CA
23152    New Orleans, LA
30387        Houston, TX
30388        Houston, TX
30390        Houston, TX
30392        Houston, TX
30393        Houston, TX
30394        Houston, TX
30395        Houston, TX
30396        Houston, TX
36310        Houston, TX
36311        Houston, TX
36312        Houston, TX
36316        Houston, TX
36317        Houston, TX
36318        Houston, TX
36319        Houston, TX
42494        Houston, TX
42498        Houston, TX
42499        Houston, TX
43072        Houston, TX
43073        Houston, TX
43335        Houston, TX
43336        Houston, TX
43337        Houston, TX
43338        Houston, TX
43339        Houston, TX
43340        Houston, TX
43941        Houston, TX
43942        Houston, TX
43945        Houston, TX
43948        Houston, TX
43949        Houston, TX
51503     Washington, DC
51504     Washington, DC
51756        Chicago, IL
51757        Chicago, IL
51759        Chicago, IL
51761        Chicago, IL
51764        Chicago, IL
52939         Newark, NJ
52941         Newark, NJ
53543  San Francisco, CA
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53548  San Francisco, CA
53549  San Francisco, CA
53550  San Francisco, CA
53551  San Francisco, CA
53552  San Francisco, CA
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We see a similar pattern on 8/31. Flights to hubs to evacuate passengers stranded in Houston. No connecting traffic.

0.5.2 Southwest

```
In [63]: houFlights[(houFlights['DATE'] == '2017-09-2')&(houFlights['STATUS']=='Completed')&(ho

Out[63]: 0    24
         1    22
         Name: INBOUND, dtype: int64

In [64]: houFlights[(houFlights['DATE'] == '2017-09-2')&(houFlights['STATUS']=='Completed')&(ho

Out[64]:       OP_CARRIER TAIL_NUM  OP_CARRIER_FL_NUM  ORIGIN_AIRPORT_ID  \
         388           WN   N203WN                744              11292
         390           WN   N7828A               2747              11292
         1717          WN   N462WN               2835              15016
         1901          WN   N8679A               4245              15304
         2473          WN   N488WN               2246              10423
         3062          WN   N8322X               5585              10821
         3179          WN   N910WN               2192              10994
         4115          WN   N627SW                 31              11259
         4116          WN   N8645A                 35              11259
         4122          WN   N390SW               2846              11259
         5118          WN   N8301J               1379              11697
         5332          WN   N640SW               5390              12206
         6252          WN   N8648A               2475              13198
         6470          WN   N264LV               3101              13204
         6800          WN   N454WN               2195              13232
         6801          WN   N8609A               2632              13232
         7375          WN   N634SW               2205              13495
         7378          WN   N468WN               3851              13495
         8049          WN   N7840A               3844              14057
         8207          WN   N8533S               5684              14107
         8568          WN   N8686A               2645              14679
         8569          WN   N920WN               4193              14679
         10342         WN   N8609A               2790              12191
         10343         WN   N931WN               3063              12191
         12888         WN   N468WN               2804              12191
         14500         WN   N627SW                 40              12191
         14501         WN   N8645A                 44              12191
         14507         WN   N8301J               1379              12191
         14510         WN   N7828A               2747              12191
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14511	WN	N640SW	5390	12191
15121	WN	N910WN	2723	12191
15682	WN	N8533S	2146	12191
15683	WN	N203WN	2266	12191
17630	WN	N634SW	2205	12191
18054	WN	N390SW	2846	12191
18337	WN	N920WN	3889	12191
19050	WN	N488WN	2246	12191
19052	WN	N8648A	2996	12191
22050	WN	N8672F	2057	12191
22053	WN	N8322X	3112	12191
22055	WN	N8679A	4245	12191
22897	WN	N264LV	3101	12191
24610	WN	N454WN	2195	12191
25418	WN	N462WN	2784	12191
27628	WN	N8686A	2645	12191
27977	WN	N7840A	3128	12191

	ORIGIN_CITY_MARKET_ID	ORIGIN	ORIGIN_CITY_NAME \
388	30325	DEN	Denver, CO
390	30325	DEN	Denver, CO
1717	31123	STL	St. Louis, MO
1901	33195	TPA	Tampa, FL
2473	30423	AUS	Austin, TX
3062	30852	BWI	Baltimore, MD
3179	30994	CHS	Charleston, SC
4115	30194	DAL	Dallas, TX
4116	30194	DAL	Dallas, TX
4122	30194	DAL	Dallas, TX
5118	32467	FLL	Fort Lauderdale, FL
5332	32206	HRL	Harlingen/San Benito, TX
6252	33198	MCI	Kansas City, MO
6470	31454	MCO	Orlando, FL
6800	30977	MDW	Chicago, IL
6801	30977	MDW	Chicago, IL
7375	33495	MSY	New Orleans, LA
7378	33495	MSY	New Orleans, LA
8049	34057	PDX	Portland, OR
8207	30466	PHX	Phoenix, AZ
8568	33570	SAN	San Diego, CA
8569	33570	SAN	San Diego, CA
10342	31453	HOU	Houston, TX
10343	31453	HOU	Houston, TX
12888	31453	HOU	Houston, TX
14500	31453	HOU	Houston, TX
14501	31453	HOU	Houston, TX
14507	31453	HOU	Houston, TX
14510	31453	HOU	Houston, TX

14511	31453	HOU	Houston, TX
15121	31453	HOU	Houston, TX
15682	31453	HOU	Houston, TX
15683	31453	HOU	Houston, TX
17630	31453	HOU	Houston, TX
18054	31453	HOU	Houston, TX
18337	31453	HOU	Houston, TX
19050	31453	HOU	Houston, TX
19052	31453	HOU	Houston, TX
22050	31453	HOU	Houston, TX
22053	31453	HOU	Houston, TX
22055	31453	HOU	Houston, TX
22897	31453	HOU	Houston, TX
24610	31453	HOU	Houston, TX
25418	31453	HOU	Houston, TX
27628	31453	HOU	Houston, TX
27977	31453	HOU	Houston, TX

	ORIGIN_STATE_ABR	ORIGIN_STATE_NM	ORIGIN_WAC	DEST_AIRPORT_ID	\
388	CO	Colorado	82	12191	
390	CO	Colorado	82	12191	
1717	MO	Missouri	64	12191	
1901	FL	Florida	33	12191	
2473	TX	Texas	74	12191	
3062	MD	Maryland	35	12191	
3179	SC	South Carolina	37	12191	
4115	TX	Texas	74	12191	
4116	TX	Texas	74	12191	
4122	TX	Texas	74	12191	
5118	FL	Florida	33	12191	
5332	TX	Texas	74	12191	
6252	MO	Missouri	64	12191	
6470	FL	Florida	33	12191	
6800	IL	Illinois	41	12191	
6801	IL	Illinois	41	12191	
7375	LA	Louisiana	72	12191	
7378	LA	Louisiana	72	12191	
8049	OR	Oregon	92	12191	
8207	AZ	Arizona	81	12191	
8568	CA	California	91	12191	
8569	CA	California	91	12191	
10342	TX	Texas	74	10397	
10343	TX	Texas	74	10397	
12888	TX	Texas	74	10994	
14500	TX	Texas	74	11259	
14501	TX	Texas	74	11259	
14507	TX	Texas	74	11259	
14510	TX	Texas	74	11259	

14511	TX	Texas	74	11259
15121	TX	Texas	74	11278
15682	TX	Texas	74	11292
15683	TX	Texas	74	11292
17630	TX	Texas	74	12206
18054	TX	Texas	74	12451
18337	TX	Texas	74	12889
19050	TX	Texas	74	12892
19052	TX	Texas	74	12892
22050	TX	Texas	74	13232
22053	TX	Texas	74	13232
22055	TX	Texas	74	13232
22897	TX	Texas	74	13495
24610	TX	Texas	74	14107
25418	TX	Texas	74	14492
27628	TX	Texas	74	15016
27977	TX	Texas	74	15304

	DEST_CITY_MARKET_ID	DEST	DEST_CITY_NAME
388	31453	HOU	Houston, TX
390	31453	HOU	Houston, TX
1717	31453	HOU	Houston, TX
1901	31453	HOU	Houston, TX
2473	31453	HOU	Houston, TX
3062	31453	HOU	Houston, TX
3179	31453	HOU	Houston, TX
4115	31453	HOU	Houston, TX
4116	31453	HOU	Houston, TX
4122	31453	HOU	Houston, TX
5118	31453	HOU	Houston, TX
5332	31453	HOU	Houston, TX
6252	31453	HOU	Houston, TX
6470	31453	HOU	Houston, TX
6800	31453	HOU	Houston, TX
6801	31453	HOU	Houston, TX
7375	31453	HOU	Houston, TX
7378	31453	HOU	Houston, TX
8049	31453	HOU	Houston, TX
8207	31453	HOU	Houston, TX
8568	31453	HOU	Houston, TX
8569	31453	HOU	Houston, TX
10342	30397	ATL	Atlanta, GA
10343	30397	ATL	Atlanta, GA
12888	30994	CHS	Charleston, SC
14500	30194	DAL	Dallas, TX
14501	30194	DAL	Dallas, TX
14507	30194	DAL	Dallas, TX
14510	30194	DAL	Dallas, TX

14511	30194	DAL	Dallas, TX
15121	30852	DCA	Washington, DC
15682	30325	DEN	Denver, CO
15683	30325	DEN	Denver, CO
17630	32206	HRL	Harlingen/San Benito, TX
18054	31136	JAX	Jacksonville, FL
18337	32211	LAS	Las Vegas, NV
19050	32575	LAX	Los Angeles, CA
19052	32575	LAX	Los Angeles, CA
22050	30977	MDW	Chicago, IL
22053	30977	MDW	Chicago, IL
22055	30977	MDW	Chicago, IL
22897	33495	MSY	New Orleans, LA
24610	30466	PHX	Phoenix, AZ
25418	34492	RDU	Raleigh/Durham, NC
27628	31123	STL	St. Louis, MO
27977	33195	TPA	Tampa, FL