In [178…

```
import pandas as pd
import numpy as np
from datetime import timedelta
import datetime
from pytz import timezone, utc
from timezonefinder import TimezoneFinder
import geopy.distance
import matplotlib.pyplot as plt
import math

plt.rcParams['font.size'] = '20'
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', 999)
```

AIR TRAVEL (March 2015-)

In [179…

```
ROOT_DIR = '/Users/alexanderguo/Desktop/picrazy2.github.io/flightlog/'
df = pd.read_csv(ROOT_DIR + 'flightlog.csv')
airports = pd.read_csv(ROOT_DIR + 'airports.csv')

tf = TimezoneFinder()

def get_offset(t, lat, lng):
    """
    returns a location's time zone offset from UTC in hours.
    """
    tz_target = timezone(tf.certain_timezone_at(lng=lng, lat=lat))
    today_target = tz_target.localize(t)
    today_utc = utc.localize(t)
    return (today_utc - today_target).total_seconds() / 3600

def get_offset_tz(t, tz_target):
    """
    returns a location's time zone offset from UTC in hours.
    """
    today_target = tz_target.localize(t)
    today_utc = utc.localize(t)
    return (today_utc - today_target).total_seconds() / 3600
```

In [180…

```
# Main Processing

df['Date'] = pd.to_datetime(df['Date'])

df = df.merge(airports[['Name', 'City', 'Country', 'IATA', 'Lat', 'Long']], l
df = df.drop(columns='IATA').rename(columns={'Name': 'Dep Name', 'Lat': 'Dep
df = df.merge(airports[['Name', 'City', 'Country', 'IATA', 'Lat', 'Long']], l
df = df.drop(columns='IATA').rename(columns={'Name': 'Arr Name', 'Lat': 'Arr
```

```
df['Distance'] = df.apply(lambda row: geopy.distance.distance((row['Dep Lat']
df['Duration'] = df.apply(lambda row: np.sum(np.multiply(np.array([int(x) for

ALL_TIME_COLS = ['Scheduled Dep Time (Local)', 'Scheduled Arr Time (Local)',
DATETIME_COLS = ['Scheduled Dep Time (Local)', 'Scheduled Arr Time (Local)',
important_cols = ['Date', 'Scheduled Dep Time (Local)', 'Scheduled Arr Time (

### Code to fix times below, it's not very clean ####
# format the time cols
for col in ALL_TIME_COLS:
    df[col] = pd.to_datetime(df[col]).dt.time
    if col in DATETIME_COLS:
        temp_col = df['Date'].astype(str)+' '+df[col].astype(str)
        temp_col = temp_col.replace('.*NaT', '', regex=True)
        df[col] = pd.to_datetime(temp_col)

# get timezones
df['Dep Timezone'] = df[['Dep Lat', 'Dep Long']].apply(lambda r: timezone(tf.
df['Arr Timezone'] = df[['Arr Lat', 'Arr Long']].apply(lambda r: timezone(tf.

# fill in UTC
for col in DATETIME_COLS:
    new_col = col.split('(')[0] + '(UTC)'
    deparr = 'Dep' if 'Dep' in col else 'Arr'
    for i, r in df.iterrows():
        if str(r[col]) != 'NaT':
            df.loc[i, new_col] = r[col]-timedelta(hours=get_offset(datetime.d

# get calculated flght times
for time_type in ['Scheduled', 'Actual']:
    df[time_type + ' difference'] = df[time_type + ' Arr Time (UTC)'] - df[ti


# adjust dep/arr times, calculate delay
temp = pd.DataFrame()
for i, r in df.iterrows():
    for time_type in ['Scheduled', 'Actual']:
        if str(r[time_type + ' difference']) != 'NaT' and r[time_type + ' dif
            r[time_type + ' Arr Time (UTC)'] = r[time_type + ' Arr Time (UTC)
    dep_delay = r['Actual Dep Time (UTC)'] - r['Scheduled Dep Time (UTC)']
    if dep_delay.days < 0 and dep_delay.seconds < 86400-3600: # can't have ac
        r['Actual Dep Time (UTC)'] = r['Actual Dep Time (UTC)'] + timedelta(d
        r['Actual Arr Time (UTC)'] = r['Actual Arr Time (UTC)'] + timedelta(d
    dep_delay = r['Actual Dep Time (UTC)'] - r['Scheduled Dep Time (UTC)']
    arr_delay = r['Actual Arr Time (UTC)'] - r['Scheduled Arr Time (UTC)']
    r['Dep Delay'] = np.nan if str(dep_delay) == 'NaT' else dep_delay.seconds
    r['Arr Delay'] = np.nan if str(arr_delay) == 'NaT' else arr_delay.seconds

    for time_type in ['Scheduled', 'Actual']:
        if str(r[time_type + ' Dep Time (Local)']) != 'NaT':
            r[time_type + ' Dep Time (Local)'] = r[time_type + ' Dep Time (UT
```

```
        if str(r[time_type + ' Arr Time (Local)']) != 'NaT':
            r[time_type + ' Arr Time (Local)'] = r[time_type + ' Arr Time (UT

    if i > 0:
        r['Time since last flight'] = r['Actual Dep Time (UTC)'] - df.loc[i-1
        r['Last flight arrival (UTC)'] = df.loc[i-1, 'Actual Arr Time (UTC)']
    temp = temp.append(r)

df = temp
df = df.drop(columns = ['Actual difference', 'Scheduled difference'])


TOTAL_DIST = df['Distance'].sum()
TOTAL_TIME = df['Duration'].sum()
NUM_FLIGHTS = df['Date'].count()
NUM_AIRLINES = df['Airline'].nunique()
NUM_COUNTRIES = len(set(df['Dep Country'].tolist()) | set(df['Arr Country'].t
NUM_AIRPORTS = len(set(df['Dep Airport'].tolist()) | set(df['Arr Airport'].to
sorted_by_flight_interval = df.sort_values('Time since last flight', ascendin
LONGEST_INTERVAL = str(sorted_by_flight_interval.loc[0, 'Time since last flig
LONGEST_INTERVAL_0 = str(sorted_by_flight_interval.loc[0, 'Last flight arriva
LONGEST_INTERVAL_1 = str(sorted_by_flight_interval.loc[0, 'Scheduled Dep Time


print('Total Distance Flown (miles): ' + str(TOTAL_DIST))
print('Total time in the air: ' + str(timedelta(minutes=int(TOTAL_TIME))))
print('Total Flights: ' + str(NUM_FLIGHTS))
print('Number of Airlines: ' + str(NUM_AIRLINES))
print('Number of Countries: ' + str(NUM_COUNTRIES))
print('Number of Airports: ' + str(NUM_AIRPORTS))
print('Longest time without flying: ' + LONGEST_INTERVAL + ', ' + LONGEST_INT

# df
```

```
Total Distance Flown (miles): 447171.1344914059
Total time in the air: 37 days, 23:33:00
Total Flights: 201
Number of Airlines: 28
Number of Countries: 27
Number of Airports: 74
Longest time without flying: 157 days 18:22:00, 2016-07-10 to 2016-12-15
```

FLIGHTS SORTED BY DISTANCE

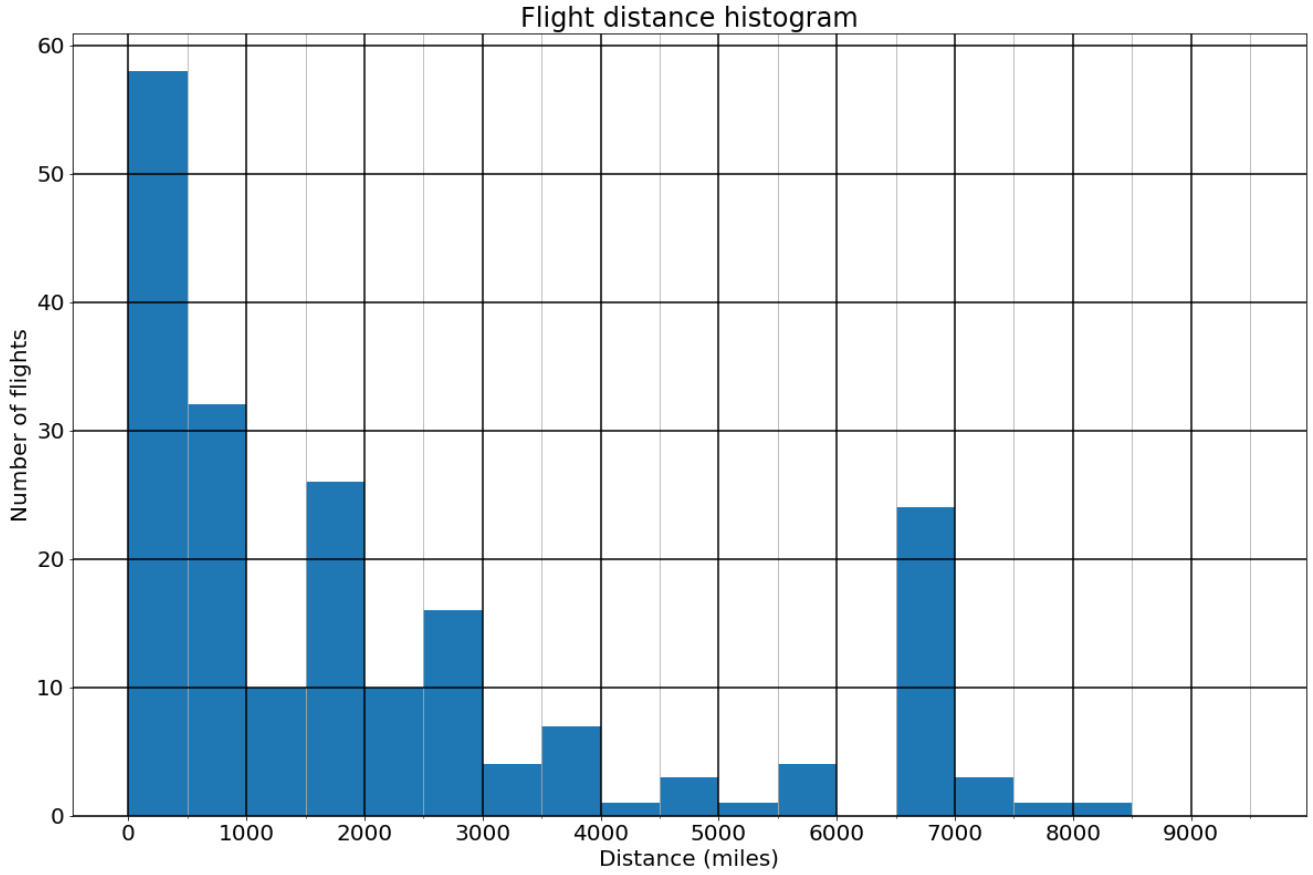
In [181…

```
fig, ax = plt.subplots(1, 1, figsize=(20,13))
bins = list(range(0, 10000, 500))
ax.hist(df['Distance'], bins=bins)
ax.set_xticks(bins, minor=True)
ax.set_xticks([b for i, b in enumerate(bins) if i%2 == 0])
ax.grid(which='major', linewidth=1.5, color='black')
ax.grid(which='minor', axis='both')
ax.set_xlabel('Distance (miles)')
ax.set_ylabel('Number of flights')
ax.set_title('Flight distance histogram')
plt.savefig('figures/distance_hist.jpg', bbox_inches='tight')

df.sort_values(['Distance'], ascending=True).head(10)[important_cols]
```

Out[181…

	Date	Scheduled Dep Time (Local)	Scheduled Arr Time (Local)	Actual Duration	Airline	Flight	Dep Airport	Arr Airport	Distance	D
64	2017-11-13	2017-11-13 06:00:00	2017-11-13 07:03:00	00:29:00	Delta	DL3854	PHL	JFK	93.709017	
57	2017-09-22	2017-09-22 08:30:00	2017-09-22 09:32:00	00:33:00	United	UA6071	IAD	PHL	134.682407	
193	2022-01-03	2022-01-03 18:10:00	2022-01-03 19:10:00	00:31:00	United	UA1778	IAH	AUS	140.223208	
29	2016-12-23	2016-12-23 21:45:00	2016-12-23 22:50:00	00:43:00	Silkair	MI341	KUL	SIN	184.712792	
65	2017-11-13	2017-11-13 09:00:00	2017-11-13 10:24:00	00:41:00	Delta	DL4010	JFK	BOS	186.718871	
107	2019-06-01	2019-06-01 16:10:00	2019-06-01 17:15:00	00:53:00	Sichuan	3U8818	LJG	KMG	199.275720	
0	2015-03-08	2015-03-08 08:34:00	2015-03-08 10:01:00	00:50:00	United	UA1711	BOS	EWR	200.540719	
34	2017-03-11	2017-03-11 07:06:00	2017-03-11 08:30:00	00:47:00	United	UA1548	BOS	EWR	200.540719	
37	2017-03-20	2017-03-20 21:52:00	2017-03-20 23:05:00	00:37:00	United	UA1775	EWR	BOS	200.540719	
117	2019-09-28	2019-09-28 20:30:00	2019-09-28 21:47:00	00:41:00	United	UA421	EWR	BOS	200.540719	



FLIGHTS SORTED BY DURATION

In [182…

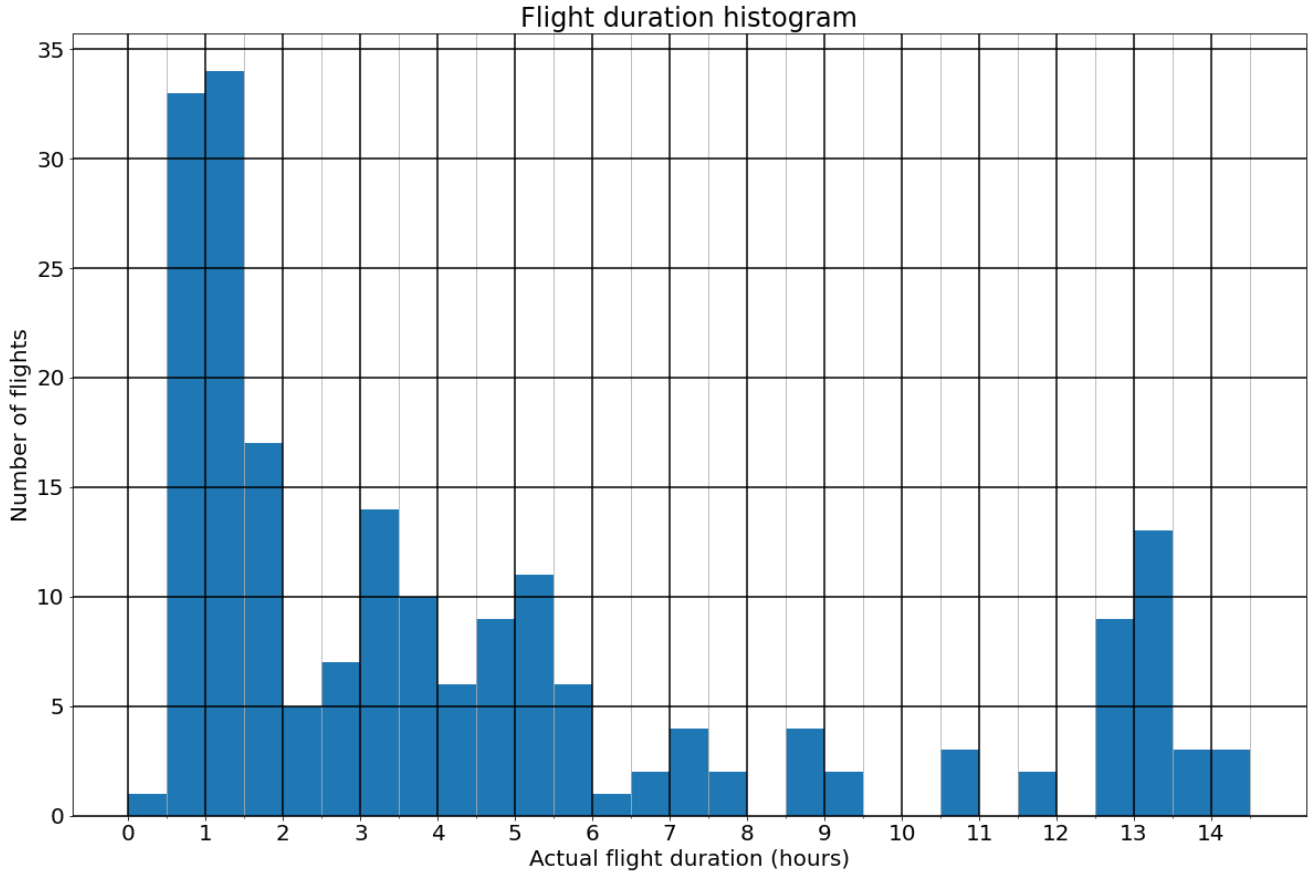
```
fig, ax = plt.subplots(1, 1, figsize=(20,13))
bins = list(range(0, math.ceil(df['Duration'].max()/30)*30+30, 30))
ax.hist(df['Duration'], bins=bins)
ax.set_xticks(bins, minor=True)
ax.set_xticks([b for i, b in enumerate(bins) if i%2 == 0])
ax.set_xticklabels([b//60 for i, b in enumerate(bins) if i%2 == 0])
ax.grid(which='major', linewidth=1.5, color='black')
ax.grid(which='minor', axis='both')
ax.set_xlabel('Actual flight duration (hours)')
ax.set_ylabel('Number of flights')
ax.set_title('Flight duration histogram')
plt.savefig('figures/duration_hist.jpg', bbox_inches='tight')

df.sort_values(['Duration'], ascending=False).head(10)[important_cols]
```

Out[182…

	Date	Scheduled Dep Time (Local)	Scheduled Arr Time (Local)	Actual Duration	Airline	Flight	Dep Airport	Arr Airport	Distance
71	2018-01-07	2018-01-07 10:00:00	2018-01-07 08:40:00	14:09:00	United	UA2	SIN	SFO	8446.305238

74	2018-03-29	2018-03-29 12:25:00	2018-03-29 14:35:00	14:03:00	Hainan	HU7961	PVG	BOS	7307.683803
73	2018-03-22	2018-03-22 16:35:00	2018-03-23 19:20:00	14:03:00	Hainan	HU7962	BOS	PVG	7307.683803
97	2019-01-06	2019-01-06 23:55:00	2019-01-07 05:05:00	13:50:00	Air Canada	AC57	DXB	YYZ	6899.002047
125	2019-12-18	2019-12-18 20:30:00	2019-12-19 18:00:00	13:34:00	United	UA1122	EWR	CPT	7816.760114
1	2015-03-08	2015-03-08 12:55:00	2015-03-09 15:00:00	13:30:00	United	UA89	EWR	PEK	6830.922824
20	2016-06-05	2016-06-05 17:10:00	2016-06-06 19:05:00	13:29:00	Hainan	HU482	BOS	PEK	6736.622183
12	2016-03-13	2016-03-13 16:50:00	2016-03-14 19:05:00	13:26:00	Hainan	HU482	BOS	PEK	6736.622183
7	2015-12-18	2015-12-18 12:00:00	2015-12-19 15:00:00	13:22:00	United	UA89	EWR	PEK	6830.922824
113	2019-08-17	2019-08-17 11:50:00	2019-08-18 13:35:00	13:17:00	United	UA89	EWR	PEK	6830.922824



ALL COUNTRIES AND AIRPORTS

In [183…

```
dep_countries = df.groupby(['Dep Country', 'Dep Airport']).agg({'Date': 'coun
dep_countries.columns = ['Country', 'Airport', 'Departures']
arr_countries = df.groupby(['Arr Country', 'Arr Airport']).agg({'Date': 'coun
arr_countries.columns = ['Country', 'Airport', 'Arrivals']
connect_countries = df[df['Arr Connect'] == 1].groupby(['Arr Country', 'Arr A
connect_countries.columns = ['Country', 'Airport', 'Connections']
countries = pd.merge(pd.merge(dep_countries, arr_countries, how='outer'), con
countries['Total Visits'] = countries['Departures'] + countries['Arrivals'] -
countries['Departures'] = countries['Departures'] - countries['Connections']
countries['Arrivals'] = countries['Arrivals'] - countries['Connections']
countries.astype('int32')
```

Out[183…

		Departures	Arrivals	Connections	Total Visits
Country	**Airport**				
Australia	**BNE**	1	1	0	2
	SYD	1	1	0	2
Bahamas	**NAS**	1	1	0	2
Bermuda	**BDA**	1	1	0	2

Canada	**YYZ**	0	0	1	1
China	**CTU**	1	1	0	2
	DNH	1	1	0	2
	HGH	1	1	0	2
	HRB	1	1	0	2
	KJI	1	1	0	2
	KMG	0	0	1	1
	KWL	1	1	0	2
	LHW	0	0	1	1
	LJG	1	1	0	2
	PEK	23	25	0	48
	PVG	2	2	0	4
	SHA	1	0	0	1
	SYX	1	1	0	2
	SZX	1	0	0	1
	URC	2	2	0	4
	WUX	1	1	0	2
	XIY	0	0	1	1
Costa Rica	**SJO**	1	1	0	2
Dominican Republic	**PUJ**	1	1	0	2
France	**CDG**	2	2	0	4
	NCE	1	1	0	2
Germany	**FRA**	0	0	2	2
	MUC	0	0	1	1
Iceland	**KEF**	1	1	0	2
Italy	**FCO**	1	1	0	2
Japan	**HND**	1	0	0	1
	KIX	1	1	0	2
	NRT	0	1	0	1
Malaysia	**KUL**	1	1	0	2
Mexico	**PVR**	1	1	0	2

Portugal	**LIS**	0	0	3	3
Puerto Rico	**SJU**	1	1	0	2
Saint Kitts and Nevis	**SKB**	1	1	0	2
Singapore	**SIN**	1	1	1	3
South Africa	**CPT**	2	1	0	3
	PLZ	0	1	0	1
South Korea	**GMP**	1	1	0	2
	ICN	1	1	0	2
Spain	**BCN**	1	1	0	2
	MAD	0	1	0	1
	VLL	1	0	0	1
Thailand	**BKK**	0	1	0	1
	DMK	1	0	0	1
Turkey	**IST**	2	2	0	4
	NAV	1	1	0	2
United Arab Emirates	**DXB**	1	1	1	3
United Kingdom	**LHR**	1	1	0	2
United States	**ANC**	1	1	0	2
	AUS	1	1	0	2
	BDL	1	1	0	2
	BOS	37	36	0	73
	DEN	1	1	5	7
	DTW	2	2	0	4
	EWR	4	4	22	30
	HNL	1	1	0	2
	IAD	0	0	7	7
	IAH	0	0	3	3
	JFK	1	1	2	4
	LAX	3	3	1	7
	LGA	1	0	0	1
	OGG	1	1	0	2
	ORD	2	2	4	8

	PHL	3	4	0	7
	RDU	1	1	0	2
	SAN	1	1	0	2
	SFO	10	11	3	24
	SGU	1	1	0	2
	SLC	1	1	0	2
Virgin Islands	**STT**	1	1	0	2

AIRPORTS SORTED BY TOTAL VISITS

In [184…

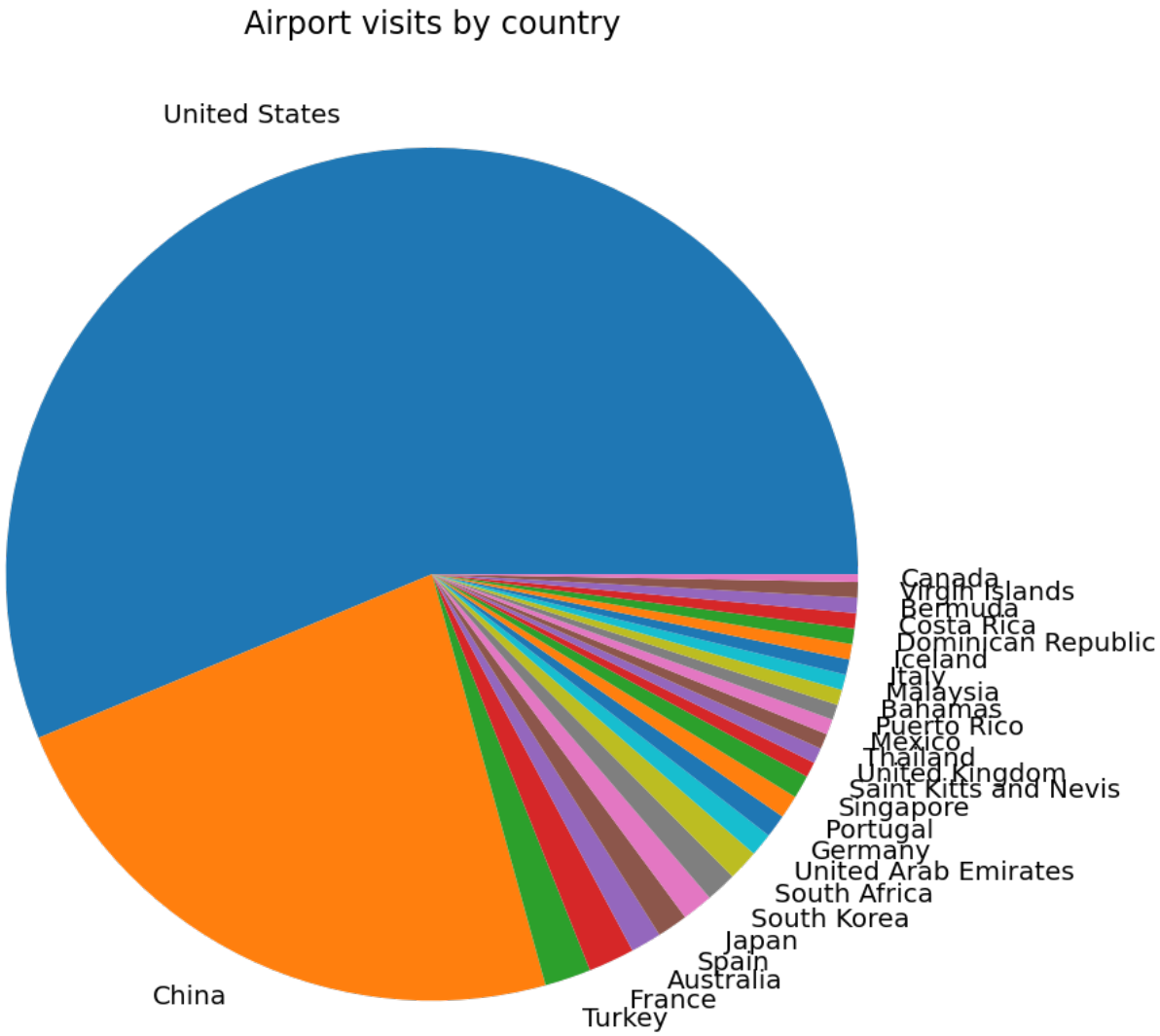
```
countries_sorted = countries.sort_values(by=['Total Visits'], ascending=False
countries_sorted = countries_sorted.astype('int32')
countries_sorted.head(20)
```

Out[184…

Country	Airport	Departures	Arrivals	Connections	Total Visits
United States	BOS	37	36	0	73
China	PEK	23	25	0	48
United States	EWR	4	4	22	30
	SFO	10	11	3	24
	ORD	2	2	4	8
	DEN	1	1	5	7
	IAD	0	0	7	7
	PHL	3	4	0	7
	LAX	3	3	1	7
	JFK	1	1	2	4
China	PVG	2	2	0	4
United States	DTW	2	2	0	4
China	URC	2	2	0	4
Turkey	IST	2	2	0	4
France	CDG	2	2	0	4
United Arab Emirates	DXB	1	1	1	3
South Africa	CPT	2	1	0	3
Singapore	SIN	1	1	1	3
Portugal	LIS	0	0	3	3
United States	IAH	0	0	3	3

In [185…

```
fig, ax = plt.subplots(1, 1, figsize=(15,15))
countries_sorted.reset_index().groupby('Country').agg({'Total Visits': sum}).
ax.set_title('Airport visits by country')
ax.set_ylabel('')
plt.savefig('figures/countries.jpg', bbox_inches='tight')
```



TOP ROUTES

In [186…

```
routes = df.groupby(['Dep Airport', 'Arr Airport']).agg({'Date': 'count', 'Di
routes.columns = ['Count', 'Total Distance']
routes.head(10)
```

Out[186…

Dep Airport	Arr Airport	Count	Total Distance
BOS	EWR	14	2807.570070
EWR	BOS	12	2406.488631
	PEK	10	68309.228239
SFO	BOS	6	16224.706890
PEK	EWR	5	34154.614120
BOS	ORD	3	2599.949013
PEK	IAD	3	20762.252704
BOS	IAD	3	1238.508572
IAD	BOS	3	1238.508572
LAX	BOS	2	5222.264116

In [187…

```
df['Sorted Route'] = df.apply(lambda row: str(sorted([row['Dep Airport'], row
routes_sorted = df.groupby('Sorted Route').agg({'Date': 'count', 'Distance':
routes_sorted.columns = ['Count', 'Total Distance']
routes_sorted.head(8)
```

Out[187…

Sorted Route	Count	Total Distance
BOS EWR	26	5214.058701
EWR PEK	15	102463.842359
BOS SFO	8	21632.942519
BOS IAD	6	2477.017144
BOS ORD	4	3466.598684
BOS DEN	4	7016.192200
BOS PHL	3	840.060616
BOS PEK	3	20209.866549

TOP AIRLINES

In [188…

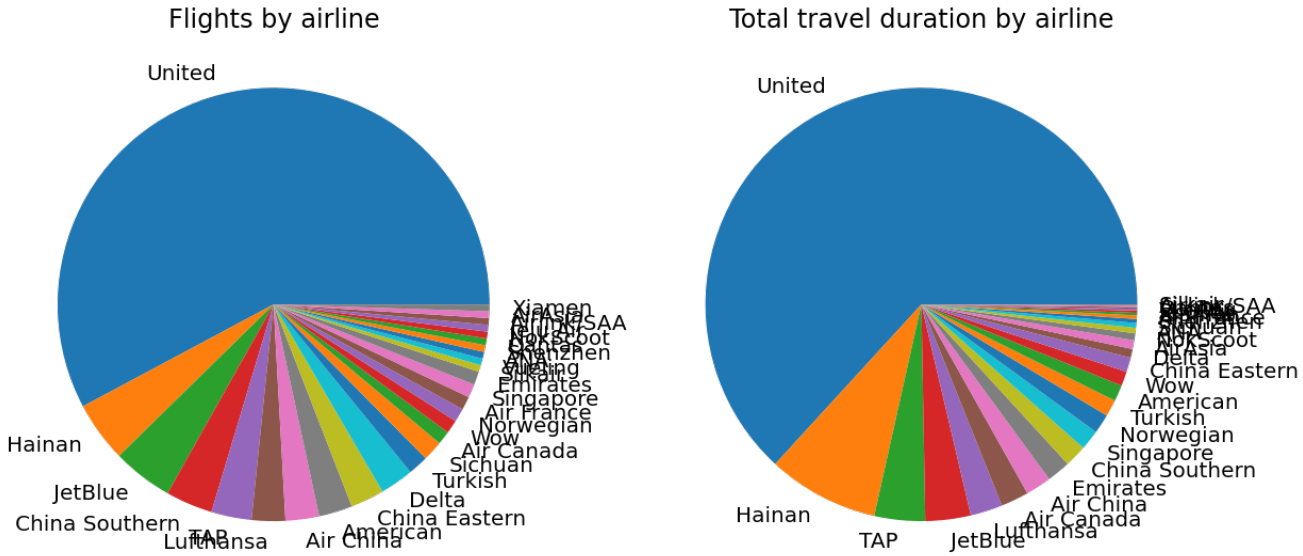
```
airlines = df.groupby(['Airline']).agg({'Date': 'count', 'Distance': sum, 'Du
airlines.columns = ['Count', 'Total Distance', 'Duration']
airlines
```

Out[188...

Airline	Count	Total Distance	Duration
United	115	285870.233467	34281.0
Hainan	9	37994.846495	4518.0
JetBlue	9	14963.728435	1844.0
China Southern	7	5826.802274	893.0
TAP	6	17163.365833	2058.0
Lufthansa	5	10712.757129	1301.0
Air China	5	6760.300960	1040.0
American	5	4662.374153	654.0
China Eastern	5	4002.392049	583.0
Delta	5	2177.481006	357.0
Turkish	3	5717.417007	676.0
Sichuan	3	1149.181213	195.0
Air Canada	2	9158.327715	1133.0
Wow	2	4825.703770	587.0
Norwegian	2	6896.709346	786.0
Air France	2	863.555358	145.0
Singapore	2	6595.899868	811.0
Emirates	2	8372.891617	955.0
Silkair	1	184.712792	43.0
Vueling	1	360.562576	75.0
ANA	1	1302.813500	220.0
Shenzhen	1	1055.947098	160.0
Qantas	1	466.532085	72.0
NokScoot	1	2582.418413	281.0
Jeju Air	1	535.417349	88.0
Airlink/SAA	1	402.774598	57.0
AirAsia	1	2733.231511	354.0
Xiamen	1	712.977038	101.0

In [189…

```
fig, ax = plt.subplots(1, 2, figsize=(20,10))
airlines.plot('Airline', 'Count', kind='pie', legend=False, ax=ax[0])
airlines.sort_values(by='Duration', ascending=False).plot('Airline', 'Duratio
ax[0].set_title('Flights by airline')
ax[1].set_title('Total travel duration by airline')
ax[0].set_ylabel('')
ax[1].set_ylabel('')
plt.savefig('figures/airlines.jpg', bbox_inches='tight')
```



TOP AIRCRAFT

In [190…

```
aircraft = df.groupby(['Aircraft']).agg({'Date': 'count', 'Distance': sum, 'D
aircraft.columns = ['Count', 'Total Distance', 'Duration']
aircraft
```

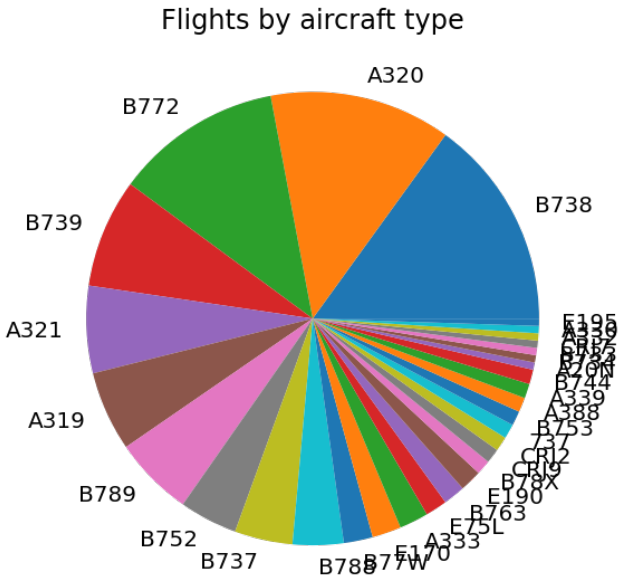
Out[190…

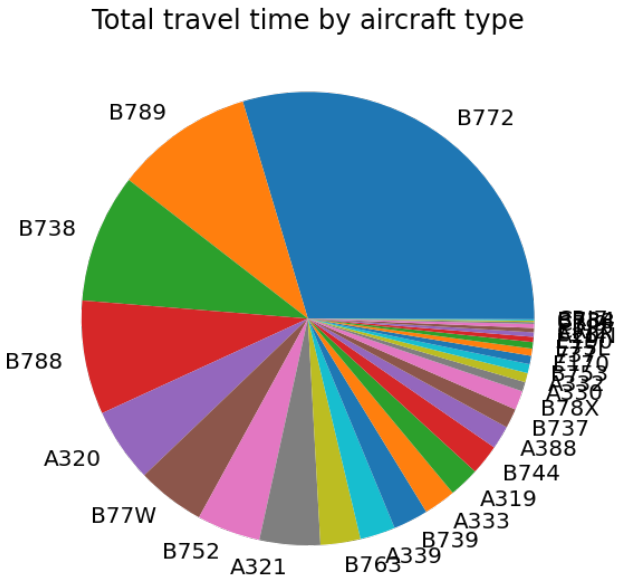
Aircraft	Count	Total Distance	Duration
B738	29	36128.311019	4876.0
A320	25	19979.216986	2804.0
B772	23	137297.180470	15708.0
B739	15	8524.368972	1326.0
A321	12	17752.133920	2293.0
A319	11	8069.656310	1150.0
B789	11	47305.905249	5233.0
B752	8	20533.794475	2407.0

B737	8	4570.832260	736.0
B788	7	36454.091790	4304.0
B77W	4	22003.857087	2579.0
E170	4	1891.991164	318.0
A333	4	8637.413616	1212.0
E75L	3	1712.474055	244.0
B763	3	13050.769729	1514.0
E190	3	1363.679260	196.0
B78X	2	6324.007060	725.0
CRJ9	2	280.427888	70.0
CRJ2	2	1034.303957	160.0
737	2	1835.789584	271.0
B753	2	2904.658534	338.0
A388	2	7590.609673	882.0
A339	2	11361.546103	1334.0
B744	2	10248.517167	1146.0
A20N	1	1145.277975	171.0
B734	1	200.540719	42.0
B733	1	200.540719	54.0
CRJ7	1	134.682407	33.0
A332	1	3191.950847	350.0
A330	1	2733.231511	354.0
E195	1	1145.277975	152.0

In [191…

```
fig, ax = plt.subplots(1, 2, figsize=(20,10))
aircraft.plot('Aircraft', 'Count', kind='pie', legend=False, ax=ax[0])
aircraft.sort_values(by='Duration', ascending=False).plot('Aircraft', 'Durati
ax[0].set_title('Flights by aircraft type')
ax[1].set_title('Total travel time by aircraft type')
ax[0].set_ylabel('')
ax[1].set_ylabel('')
plt.savefig('figures/aircrafts.jpg', bbox_inches='tight')
```





TOP AIRCRAFT REGS

In [192…

```
reg = df.groupby(['Registration', 'Aircraft']).agg({'Date': 'count', 'Distanc
reg.columns = ['Count', 'Total Distance']
reg
```

Out[192...

Registration	Aircraft	Count	Total Distance
N78005	**B772**	3	20492.768472
N19136	**B752**	2	5408.235630
B2750	**B788**	2	14044.305986
N76010	**B772**	2	13661.845648
B7880	**B789**	2	1364.555397
N69020	**B772**	2	9249.750914
N33284	**B738**	2	1954.588769
N975JT	**A321**	2	3228.308085
N68842	**B739**	2	2314.623049
N458UA	**A320**	2	846.738773
N78008	**B772**	2	13661.845648
N646RW	**E170**	1	200.540719
N647UA	**B763**	1	3903.840400
N64809	**B739**	1	200.540719
N657UA	**B763**	1	4243.524018

TRAVEL BY YEAR

In [193...

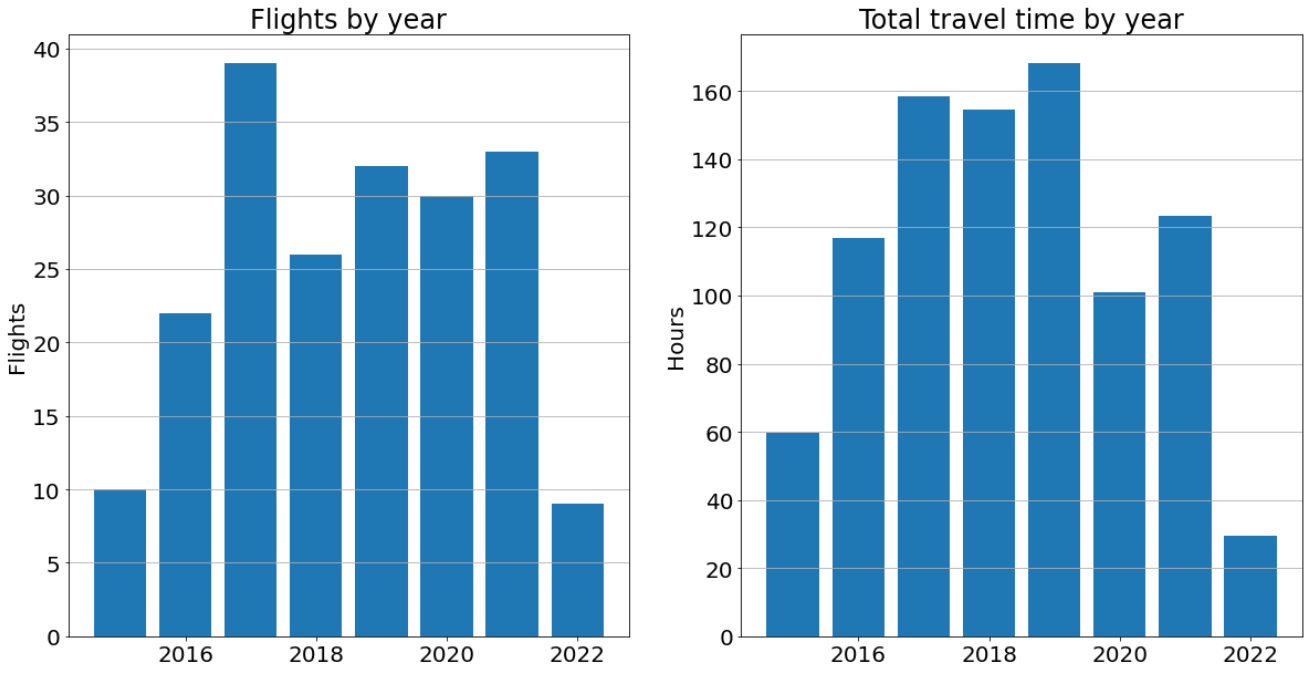
```
dist_year = df.groupby(df['Date'].dt.year).agg({'Distance': sum, 'Duration':
dist_year.columns = ['Distance', 'Duration', 'Flights']
missing_years = set(range(dist_year.index.min(), dist_year.index.max())) - se
for yr in missing_years:
    dist_year = dist_year.append(pd.DataFrame({'Distance': 0, 'Duration': 0,
dist_year
```

Out[193…

Date	Distance	Duration	Flights
2015	29436.434579	3573.0	10
2016	58570.729684	7014.0	22
2017	78048.415226	9502.0	39
2018	77923.939884	9277.0	26
2019	84244.238494	10091.0	32
2020	48040.013756	6065.0	30
2021	58951.069745	7405.0	33
2022	11956.293123	1766.0	9

In [194…

```
fig, ax = plt.subplots(1, 2, figsize=(20,10))
ax[0].bar(dist_year.index, dist_year['Flights'])
ax[0].grid(axis='y')
ax[0].set_title('Flights by year')
ax[0].set_ylabel('Flights')
ax[1].bar(dist_year.index, dist_year['Duration']/60)
ax[1].grid(axis='y')
ax[1].set_title('Total travel time by year')
ax[1].set_ylabel('Hours')
plt.savefig('figures/by_year.jpg', bbox_inches='tight')
```



TRAVEL BY MONTH

In [195…

```
df['Month'] = df['Date']
dist_yearm = df.groupby([df['Date'].dt.year, df['Month'].dt.month]).agg({'Dis
dist_yearm.columns = ['Distance', 'Duration', 'Flights']

dist_yearm.sort_values(by='Distance', ascending=False).head(30)
```

Out[195…

		Distance	Duration	Flights
Date	**Month**			
2019	**12**	20870.665731	2402.0	7
2021	**6**	18558.120149	2313.0	10
2016	**3**	17481.756684	2162.0	8
2018	**3**	17028.219491	1969.0	3
2019	**8**	15448.226232	1750.0	3
2020	**1**	14596.349780	1782.0	8
2021	**11**	14545.201558	1794.0	6
2017	**10**	14365.050635	1696.0	4
2016	**12**	14231.539360	1762.0	6
2015	**3**	14062.927086	1673.0	4
2018	**10**	14062.927086	1667.0	4
2017	**3**	14062.927086	1610.0	4
2016	**7**	12787.224365	1462.0	5
2018	**12**	11672.966019	1551.0	3
	1	11150.423053	1152.0	2
2015	**12**	10151.243377	1281.0	4
2017	**1**	10099.097863	1067.0	2
2021	**5**	9973.930007	1252.0	7
2017	**12**	9811.763983	1186.0	3
2019	**11**	9497.808366	1176.0	4
2018	**5**	9363.020046	1102.0	5
2019	**1**	9158.327715	1133.0	2
2020	**11**	9014.014088	1109.0	3

2018	**6**	8759.541167	1047.0	4
2019	**5**	8348.311894	1034.0	3
	6	8330.570778	1020.0	3
2020	**8**	8318.736522	1007.0	4
2019	**3**	7760.264704	931.0	4
2016	**1**	7333.587092	819.0	2
2022	**2**	7246.612764	1044.0	4

In [196…

```
months = df['Month'].sort_values()
start_month = months.iloc[0]
end_month = months.iloc[-1]

index = pd.period_range(start_month, end_month, freq='M')
index_str = pd.DataFrame(index.astype(str), columns=['Y-M'])
# dist_yearm.reindex(index)

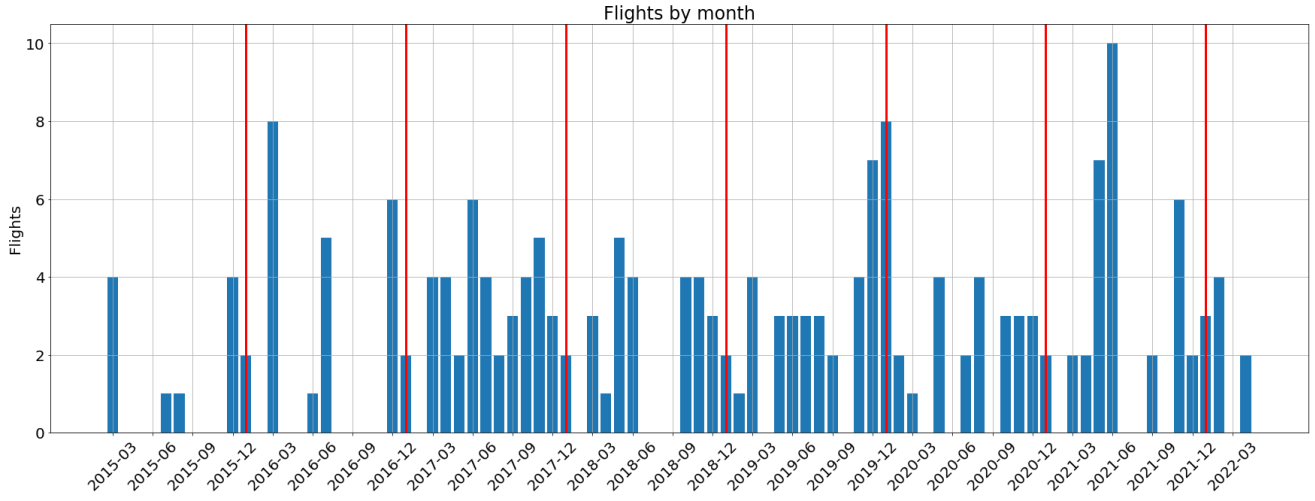
a = dist_yearm.reset_index()
a['Date'] = a['Date'].astype('int32').astype(str)
a['Month'] = a['Month'].astype('str').str.zfill(2)

a['Y-M'] = a['Date'] + '-' + a['Month']
a = a.merge(index_str, how='outer').sort_values(['Y-M']).fillna(0)

fig, ax = plt.subplots(figsize=(30,10))
ax.bar(a['Y-M'], a['Flights'], linewidth=5)
ticks = [x for i, x in enumerate(list(a['Y-M'])) if i % 3 == 0]
ax.set_xticks(ticks)
ax.set_xticklabels(ticks, rotation=45)
ax.set_ylabel('Flights')
ax.set_title('Flights by month')
ax.grid(True)


for year in range(df['Date'].dt.year.min(), df['Date'].dt.year.max()+1):
    if str(year) + '-01' in a['Y-M'].tolist():
        ax.axvline(str(year) + '-01', linewidth=3, color='red')

plt.savefig('figures/flights_by_month.jpg', bbox_inches='tight')
```

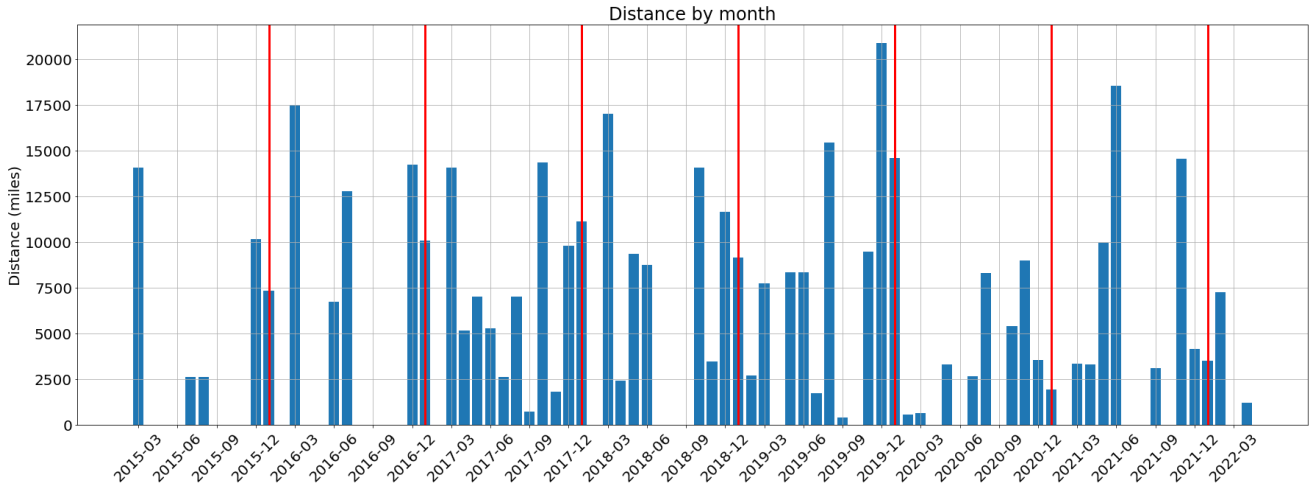


In [197…

```
fig, ax = plt.subplots(figsize=(30,10))
ax.bar(a['Y-M'], a['Distance'], linewidth=5)
ticks = [x for i, x in enumerate(list(a['Y-M'])) if i % 3 == 0]
ax.set_xticks(ticks)
ax.set_xticklabels(ticks, rotation=45)
ax.set_ylabel('Distance (miles)')
ax.set_title('Distance by month')
ax.grid(True)


for year in range(df['Date'].dt.year.min(), df['Date'].dt.year.max()+1):
    if str(year) + '-01' in a['Y-M'].tolist():
        ax.axvline(str(year) + '-01', linewidth=3, color='red')

plt.savefig('figures/distance_month.jpg', bbox_inches='tight')
```

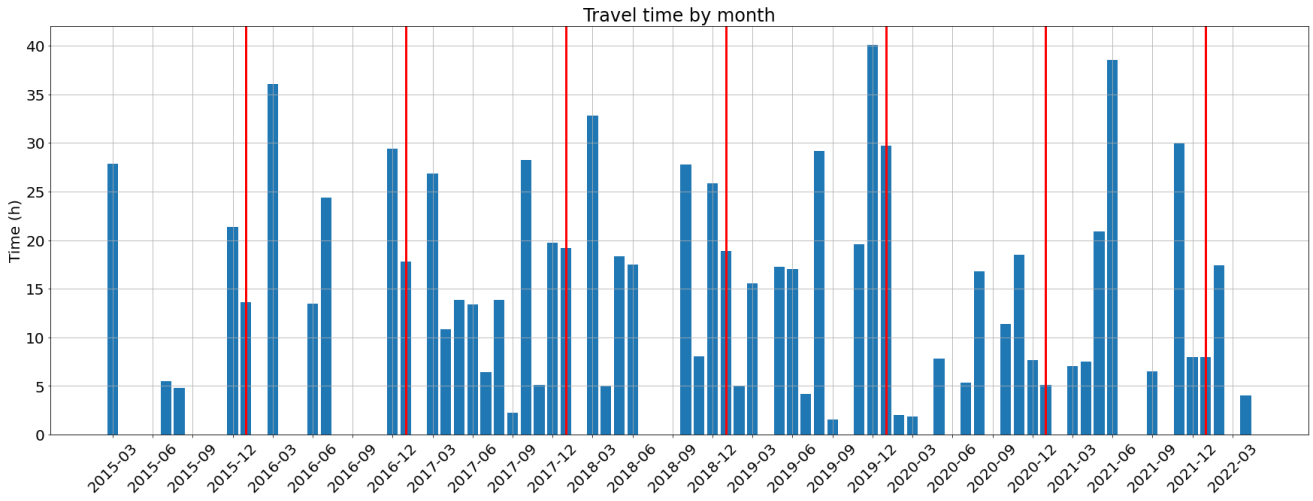


In [198…

```
fig, ax = plt.subplots(figsize=(30,10))
ax.bar(a['Y-M'], a['Duration']/60, linewidth=5)
ticks = [x for i, x in enumerate(list(a['Y-M'])) if i % 3 == 0]
ax.set_xticks(ticks)
ax.set_xticklabels(ticks, rotation=45)
ax.set_ylabel('Time (h)')
ax.set_title('Travel time by month')
ax.grid(True)


for year in range(df['Date'].dt.year.min(), df['Date'].dt.year.max()+1):
    if str(year) + '-01' in a['Y-M'].tolist():
        ax.axvline(str(year) + '-01', linewidth=3, color='red')

plt.savefig('figures/time_month.jpg', bbox_inches='tight')
```



DOMESTIC AND INTERNATIONAL BREAKDOWN

In [199…

```
dom_int = df.groupby('Domestic/International').agg({'Distance': sum, 'Date':
dom_int.columns = ['Distance', 'Flights']
dom_int
```

Out[199…

Domestic/International	Distance	Flights
Domestic	133879.086573	128
International	313292.047918	73

In [200…

```
print('Domestic average dist: ' + str(dom_int.loc['Domestic', 'Distance'] / d
print('International average dist: ' + str(dom_int.loc['International', 'Dist
```

```
Domestic average dist: 1045.930363852303
International average dist: 4291.671889291932
```

In [201…

```
year_dom_int = df.groupby([df['Date'].dt.year, 'Domestic/International']).agg
year_dom_int.columns = ['Distance', 'Flights']
year_dom_int
```

Out[201…

Date	Domestic/International	Distance	Flights
2015	**Domestic**	8943.666107	7
	International	20492.768472	3
2016	**Domestic**	11296.768030	13
	International	47273.961655	9
2017	**Domestic**	18719.510846	28
	International	59328.904380	11
2018	**Domestic**	7371.939874	11
	International	70552.000010	15
2019	**Domestic**	16722.896473	17
	International	67521.342021	15
2020	**Domestic**	35641.590777	24
	International	12398.422979	6
2021	**Domestic**	28859.795613	22
	International	30091.274133	11
2022	**Domestic**	6322.918853	6
	International	5633.374271	3

In [202…

```
clas = df.groupby('Class').agg({'Distance': sum, 'Date': 'count'})
clas.columns = ['Distance', 'Flights']
clas
```

Out[202...

Class	Distance	Flights
Business	159330.557878	54
Economy	278823.552497	141
Premium	2418.828090	1

FARE CLASS BREAKDOWN

In [203...

```
year_clas = df.groupby([df['Date'].dt.year, 'Class']).agg({'Distance': sum, '
year_clas.columns = ['Distance', 'Flights']
year_clas
```

Out[203...

Date	Class	Distance	Flights
2015	**Business**	401.081439	2
	Economy	29035.353141	8
2016	**Business**	27053.538848	6
	Economy	31517.190836	16
2017	**Business**	26942.325389	7
	Economy	51106.089836	32
2018	**Business**	18262.603286	7
	Economy	59661.336598	19
2019	**Business**	38705.464773	9
	Economy	45538.773721	23
2020	**Business**	20535.636355	11
	Economy	27504.377401	19
2021	**Business**	22071.810690	8
	Economy	34460.430966	24
	Premium	2418.828090	1
2022	**Business**	5358.097097	4

CLASS AND TRIP TYPE BREAKDOWN

In [204…

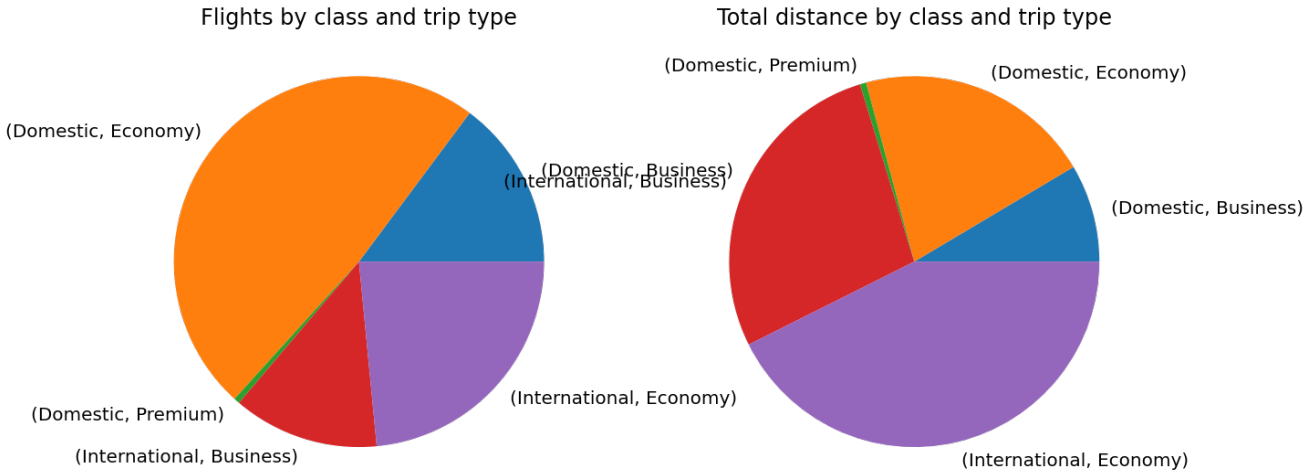
```
clas_dom_int = df.groupby(['Domestic/International', 'Class']).agg({'Distance
clas_dom_int.columns = ['Distance', 'Flights']
clas_dom_int
```

Out[204…

		Distance	Flights
Domestic/International	**Class**		
Domestic	**Business**	37549.918096	29
	Economy	91077.445336	95
	Premium	2418.828090	1
International	**Business**	121780.639782	25
	Economy	187746.107162	46

In [205…

```
fig, ax = plt.subplots(1, 2, figsize=(20,10))
clas_dom_int.plot('Class', 'Flights', kind='pie', legend=False, ax=ax[0])
clas_dom_int.plot('Class', 'Distance', kind='pie', legend=False, ax=ax[1])
ax[0].set_title('Flights by class and trip type')
ax[1].set_title('Total distance by class and trip type')
ax[0].set_ylabel('')
ax[1].set_ylabel('')
plt.savefig('figures/class_and_type.jpg', bbox_inches='tight')
```



DEP, ARR TIMES, DELAYS

In [206…

```
# ARRIVAL DEAYS

early_arrivals = df[df['Arr Delay'] < 0].shape[0]
on_time_arrivals = df[(df['Arr Delay'] >= 0) & (df['Arr Delay'] < 15)].shape[
late_arrivals = df[(df['Arr Delay'] >= 15) & (df['Arr Delay'] < 60)].shape[0]
really_late_arrivals = df[df['Arr Delay'] >= 60].shape[0]

print('Early arrivals:', early_arrivals, str(round(100*early_arrivals/NUM_FLI
print('On time arrivals (within 15 min):', on_time_arrivals, str(round(100*on
print('Late arrivals:', late_arrivals, str(round(100*late_arrivals/NUM_FLIGHT
print('Really late arrivals (1+hour):', really_late_arrivals, str(round(100*r

df.sort_values('Arr Delay', ascending=False).head(50)[important_cols]
```

```
Early arrivals: 140 70%
On time arrivals (within 15 min): 28 14%
Late arrivals: 19 9%
Really late arrivals (1+hour): 6 3%
```

Out[206…

	Date	Scheduled Dep Time (Local)	Scheduled Arr Time (Local)	Actual Duration	Airline	Flight	Dep Airport	Arr Airport	Distanc
148	2020-08-28	2020-08-28 23:45:00	2020-08-29 06:51:00	04:28:00	United	UA1104	ANC	DEN	2405.3202
35	2017-03-11	2017-03-11 12:00:00	2017-03-12 15:00:00	12:44:00	United	UA89	EWR	PEK	6830.92282
175	2021-06-04	2021-06-04 15:10:00	2021-06-04 16:21:00	00:47:00	United	UA3433	EWR	BOS	200.54071
137	2020-02-19	2020-02-19 06:46:00	2020-02-19 08:25:00	01:16:00	JetBlue	B6159	BOS	PHL	280.02020
125	2019-12-18	2019-12-18 20:30:00	2019-12-19 18:00:00	13:34:00	United	UA1122	EWR	CPT	7816.76011
76	2018-04-02	2018-04-02 15:30:00	2018-04-02 17:35:00	05:04:00	Wow	WW125	KEF	BOS	2412.85188
45	2017-06-09	2017-06-09 08:40:00	2017-06-09 09:45:00	01:06:00	China Southern	CZ6613	URC	KJI	298.92189
51	2017-07-19	2017-07-19 22:10:00	2017-07-20 00:30:00	01:37:00	Hainan	HU7610	PVG	PEK	682.27769
97	2019-	2019-01-06	2019-01-07	13:50:00	Air	AC57	DXB	YYZ	6899.00204

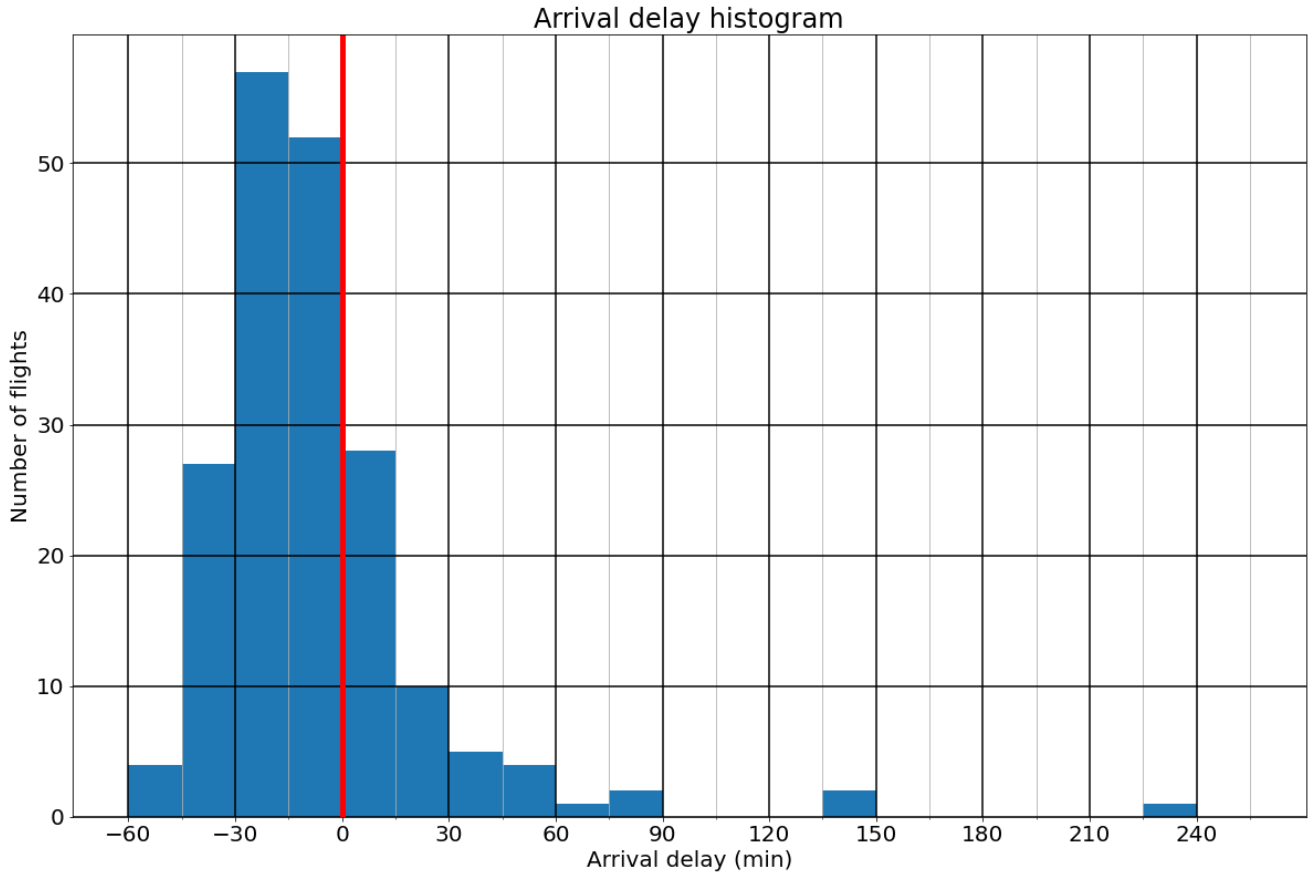
	01-06	23:55:00	05:05:00		Canada				
79	2018-05-28	2018-05-28 12:05:00	2018-05-28 13:25:00	01:15:00	Vueling	VY1585	VLL	BCN	360.56257
188	2021-11-27	2021-11-27 06:05:00	2021-11-27 08:10:00	02:51:00	TAP	TP837	FCO	LIS	1145.27797
101	2019-03-28	2019-03-28 15:20:00	2019-03-28 16:50:00	01:10:00	Air France	AF7706	CDG	NCE	431.77767
179	2021-06-15	2021-06-15 08:55:00	2021-06-15 10:06:00	01:05:00	United	UA697	EWR	BOS	200.54071
93	2018-11-26	2018-11-26 19:25:00	2018-11-26 20:42:00	00:46:00	United	UA2323	EWR	BOS	200.54071
48	2017-06-24	2017-06-24 08:10:00	2017-06-24 11:30:00	01:37:00	China Southern	CZ317	PEK	GMP	577.17514
61	2017-10-10	2017-10-10 18:25:00	2017-10-10 19:50:00	13:11:00	United	UA808	PEK	IAD	6920.75090
78	2018-05-27	2018-05-27 09:15:00	2018-05-27 11:25:00	00:51:00	TAP	TP1016	LIS	MAD	319.31293
47	2017-06-15	2017-06-15 08:10:00	2017-06-15 11:45:00	03:34:00	China Southern	CZ6911	URC	PEK	1513.75548
158	2020-12-19	2020-12-19 08:42:00	2020-12-19 14:02:00	03:36:00	United	UA1562	EWR	SKB	1749.46785
74	2018-03-29	2018-03-29 12:25:00	2018-03-29 14:35:00	14:03:00	Hainan	HU7961	PVG	BOS	7307.68380
99	2019-02-01	2019-02-01 23:10:00	2019-02-02 07:46:00	05:00:00	United	UA2360	SFO	BOS	2704.11781
54	2017-08-12	2017-08-12 15:35:00	2017-08-12 17:10:00	13:05:00	United	UA88	PEK	EWR	6830.92282
3	2015-03-19	2015-03-19 20:32:00	2015-03-19 21:46:00	00:42:00	United	UA1409	EWR	BOS	200.54071
		2019-06-	2019-06-						

108	2019-06-01	01 20:20:00	01 23:35:00	03:03:00	China Eastern	MU2570	KMG	PEK	1300.37223
186	2021-11-20	2021-11-20 16:40:00	2021-11-21 11:30:00	10:43:00	TAP	TP236	SFO	LIS	5680.77305
149	2020-08-29	2020-08-29 13:51:00	2020-08-29 19:51:00	03:20:00	United	UA217	DEN	BOS	1754.04805
157	2020-12-18	2020-12-18 16:10:00	2020-12-18 17:30:00	00:54:00	United	UA572	BOS	EWR	200.54071
46	2017-06-10	2017-06-10 21:55:00	2017-06-10 23:10:00	01:03:00	China Southern	CZ6620	KJI	URC	298.92189
180	2021-06-29	2021-06-29 15:00:00	2021-06-29 16:36:00	01:04:00	United	UA1470	BOS	IAD	412.83619
23	2016-07-06	2016-07-06 15:35:00	2016-07-06 17:12:00	01:02:00	American	AA4611	RDU	PHL	336.79598
81	2018-05-30	2018-05-30 19:15:00	2018-05-31 10:35:00	08:52:00	Lufthansa	LH722	MUC	PEK	4810.30923
1	2015-03-08	2015-03-08 12:55:00	2015-03-09 15:00:00	13:30:00	United	UA89	EWR	PEK	6830.92282
27	2016-12-15	2016-12-15 12:00:00	2016-12-16 15:00:00	13:11:00	United	UA89	EWR	PEK	6830.92282
52	2017-07-24	2017-07-24 10:30:00	2017-07-24 12:45:00	01:41:00	China Eastern	MU2949	PEK	WUX	629.91312
34	2017-03-11	2017-03-11 07:06:00	2017-03-11 08:30:00	00:47:00	United	UA1548	BOS	EWR	200.54071
178	2021-06-14	2021-06-14 16:40:00	2021-06-15 08:10:00	09:00:00	United	UA43	OGG	EWR	4903.40531
132	2020-01-19	2020-01-19 13:05:00	2020-01-19 14:20:00	01:45:00	Air China	CA124	ICN	PEK	561.98666
115	2019-08-25	2019-08-25 23:45:00	2019-08-26 08:23:00	05:06:00	United	UA235	SFO	BOS	2704.11781

68	2017-12-19	2017-12-19 19:05:00	2017-12-19 20:38:00	01:02:00	United	UA2047	BOS	EWR	200.54071
123	2019-12-02	2019-12-02 11:00:00	2019-12-02 13:10:00	07:25:00	Lufthansa	LH422	FRA	BOS	3669.63951
6	2015-12-18	2015-12-18 07:50:00	2015-12-18 09:24:00	00:54:00	United	UA1928	BOS	EWR	200.54071
177	2021-06-09	2021-06-09 11:40:00	2021-06-09 14:37:00	06:41:00	United	UA1736	DEN	OGG	3302.36199
31	2016-12-29	2016-12-29 17:35:00	2016-12-29 20:10:00	01:12:00	Qantas	QF551	BNE	SYD	466.53208
124	2019-12-18	2019-12-18 16:00:00	2019-12-18 17:44:00	00:54:00	United	UA1425	BOS	EWR	200.54071
30	2016-12-24	2016-12-24 00:45:00	2016-12-24 10:45:00	07:41:00	Singapore	SQ255	SIN	BNE	3815.59942
161	2021-03-12	2021-03-12 15:24:00	2021-03-12 20:23:00	03:20:00	JetBlue	B6261	BOS	SJU	1674.23805
150	2020-10-14	2020-10-14 08:20:00	2020-10-14 11:46:00	06:27:00	United	UA531	BOS	SFO	2704.11781
26	2016-12-15	2016-12-15 09:15:00	2016-12-15 10:35:00	00:41:00	United	UA1710	BOS	EWR	200.54071
131	2020-01-17	2020-01-17 11:50:00	2020-01-17 13:50:00	01:28:00	Jeju Air	7C1301	KIX	ICN	535.41734
182	2021-09-04	2021-09-04 08:45:00	2021-09-04 14:31:00	03:21:00	United	UA1212	SFO	PVR	1554.17468

In [207…

```
bins = list(range(-60, math.ceil(df['Arr Delay'].max()/30)*30+30, 15))
fig, ax = plt.subplots(figsize=(20,13))
ax.hist(df['Arr Delay'], bins=bins)
ax.set_xticks(bins, minor=True)
ax.set_xticks([b for i, b in enumerate(bins) if b%2 == 0])
ax.grid(which='major', linewidth=1.5, color='black')
ax.grid(which='minor', axis='both')
ax.set_xlabel('Arrival delay (min)')
ax.set_ylabel('Number of flights')
ax.set_title('Arrival delay histogram')
ax.axvline(0, linewidth=5, color='red')
plt.savefig('figures/arrival_delay.jpg', bbox_inches='tight')
```



In [208…

```
# DEPARTURE DELAYS

early_departures = df[df['Dep Delay'] < 0].shape[0]
on_time_departures = df[(df['Dep Delay'] >= 0) & (df['Dep Delay'] < 15)].shap
late_departures = df[(df['Dep Delay'] >= 15) & (df['Dep Delay'] < 60)].shape[
really_late_departures = df[df['Dep Delay'] >= 60].shape[0]


print('Early departures:', early_departures, str(round(100*early_departures/N
print('On time departures (within 15 min):', on_time_departures, str(round(10
print('Late departures:', late_departures, str(round(100*late_departures/NUM_
print('Really late departures (1+hour):', really_late_departures, str(round(1

df.sort_values('Dep Delay', ascending=False).head(10)[important_cols]
```

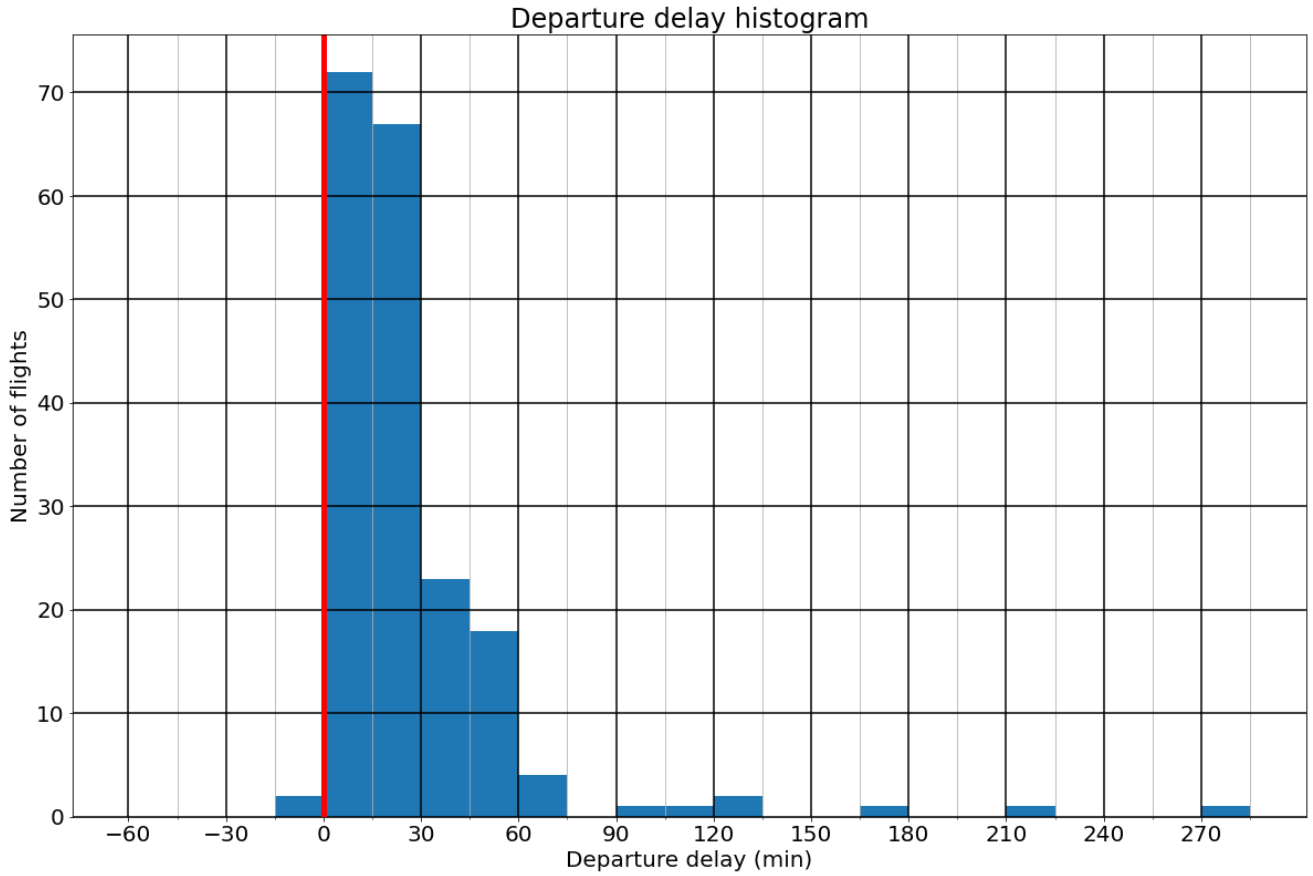
```
Early departures: 2 1%
On time departures (within 15 min): 72 36%
Late departures: 108 54%
Really late departures (1+hour): 11 5%
```

Out[208…

	Date	Scheduled Dep Time (Local)	Scheduled Arr Time (Local)	Actual Duration	Airline	Flight	Dep Airport	Arr Airport	Distance
148	2020-08-28	2020-08-28 23:45:00	2020-08-29 06:51:00	04:28:00	United	UA1104	ANC	DEN	2405.320211
35	2017-03-11	2017-03-11 12:00:00	2017-03-12 15:00:00	12:44:00	United	UA89	EWR	PEK	6830.922824
175	2021-06-04	2021-06-04 15:10:00	2021-06-04 16:21:00	00:47:00	United	UA3433	EWR	BOS	200.540719
125	2019-12-18	2019-12-18 20:30:00	2019-12-19 18:00:00	13:34:00	United	UA1122	EWR	CPT	7816.760114
76	2018-04-02	2018-04-02 15:30:00	2018-04-02 17:35:00	05:04:00	Wow	WW125	KEF	BOS	2412.851885
137	2020-02-19	2020-02-19 06:46:00	2020-02-19 08:25:00	01:16:00	JetBlue	B6159	BOS	PHL	280.020205
51	2017-07-19	2017-07-19 22:10:00	2017-07-20 00:30:00	01:37:00	Hainan	HU7610	PVG	PEK	682.277699
97	2019-01-06	2019-01-06 23:55:00	2019-01-07 05:05:00	13:50:00	Air Canada	AC57	DXB	YYZ	6899.002047
48	2017-06-24	2017-06-24 08:10:00	2017-06-24 11:30:00	01:37:00	China Southern	CZ317	PEK	GMP	577.175145
158	2020-12-19	2020-12-19 08:42:00	2020-12-19 14:02:00	03:36:00	United	UA1562	EWR	SKB	1749.467856

In [209…

```
bins = list(range(-60, math.ceil(df['Dep Delay'].max()/30)*30+30, 15))
fig, ax = plt.subplots(figsize=(20,13))
ax.hist(df['Dep Delay'], bins=bins)
ax.set_xticks(bins, minor=True)
ax.set_xticks([b for i, b in enumerate(bins) if b%2 == 0])
ax.grid(which='major', linewidth=1.5, color='black')
ax.grid(which='minor', axis='both')
ax.set_xlabel('Departure delay (min)')
ax.set_ylabel('Number of flights')
ax.set_title('Departure delay histogram')
ax.axvline(0, linewidth=5, color='red')
plt.savefig('figures/departure_delay.jpg', bbox_inches='tight')
```



DEPARTURE/ARRIVAL TIMES

In [210…

```
morning_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 5) & (df['S
afternoon_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 12) & (df
evening_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 18) & (df['
late_night_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 23) | (d

print('Morning flights (5a-12p): ' + str(morning_flights) + ', ' + str(int(ro
print('Afternoon flights (12p-6p): ' + str(afternoon_flights) + ', ' + str(in
print('Evening flights (6p-11p): ' + str(evening_flights) + ', ' + str(int(ro
```

```
print('Late nights flights (11p-5a): ' + str(late_night_flights) + ', ' + str

df['Scheduled dep hour'] = df['Scheduled Dep Time (Local)'].dt.hour
df['Scheduled arr hour'] = df['Scheduled Arr Time (Local)'].dt.hour
df['Actual dep hour'] = df['Actual Dep Time (Local)'].dt.hour
df['Actual arr hour'] = df['Actual Arr Time (Local)'].dt.hour

scheduled_dep_hour = df.groupby('Scheduled dep hour') .agg({'Date': 'count'})
for h in set(range(0, 24)) - set(scheduled_dep_hour['Hour']):
    scheduled_dep_hour = scheduled_dep_hour.append(pd.DataFrame({'Hour': h, '
scheduled_dep_hour = scheduled_dep_hour.sort_values(by='Hour')

scheduled_arr_hour = df.groupby('Scheduled arr hour').agg({'Date': 'count'}).
for h in set(range(0, 24)) - set(scheduled_arr_hour['Hour']):
    scheduled_arr_hour = scheduled_arr_hour.append(pd.DataFrame({'Hour': h, '
scheduled_arr_hour = scheduled_arr_hour.sort_values(by='Hour')

actual_dep_hour = df.groupby('Actual dep hour').agg({'Date': 'count'}).reset_
for h in set(range(0, 24)) - set(actual_dep_hour['Hour']):
    actual_dep_hour = actual_dep_hour.append(pd.DataFrame({'Hour': h, 'Count'
actual_dep_hour = actual_dep_hour.sort_values(by='Hour')

actual_arr_hour = df.groupby('Actual arr hour').agg({'Date': 'count'}).reset_
for h in set(range(0, 24)) - set(actual_arr_hour['Hour']):
    actual_arr_hour = actual_arr_hour.append(pd.DataFrame({'Hour': h, 'Count'
actual_arr_hour = actual_arr_hour.sort_values(by='Hour')

fig, ax = plt.subplots(2, 2, figsize=(20,20))
ax[0, 0].plot(scheduled_dep_hour['Hour'], scheduled_dep_hour['Count'], linewi
ax[0, 0].grid(True)
ax[0, 0].set_xticks(range(0,24,4))
ax[0, 0].set_xlabel('Hour')
ax[0, 0].set_yticks(np.arange(min(scheduled_dep_hour['Count']), max(scheduled
ax[0, 0].set_ylabel('Flights')
ax[0, 0].set_title('Flights by scheduled departure hour')

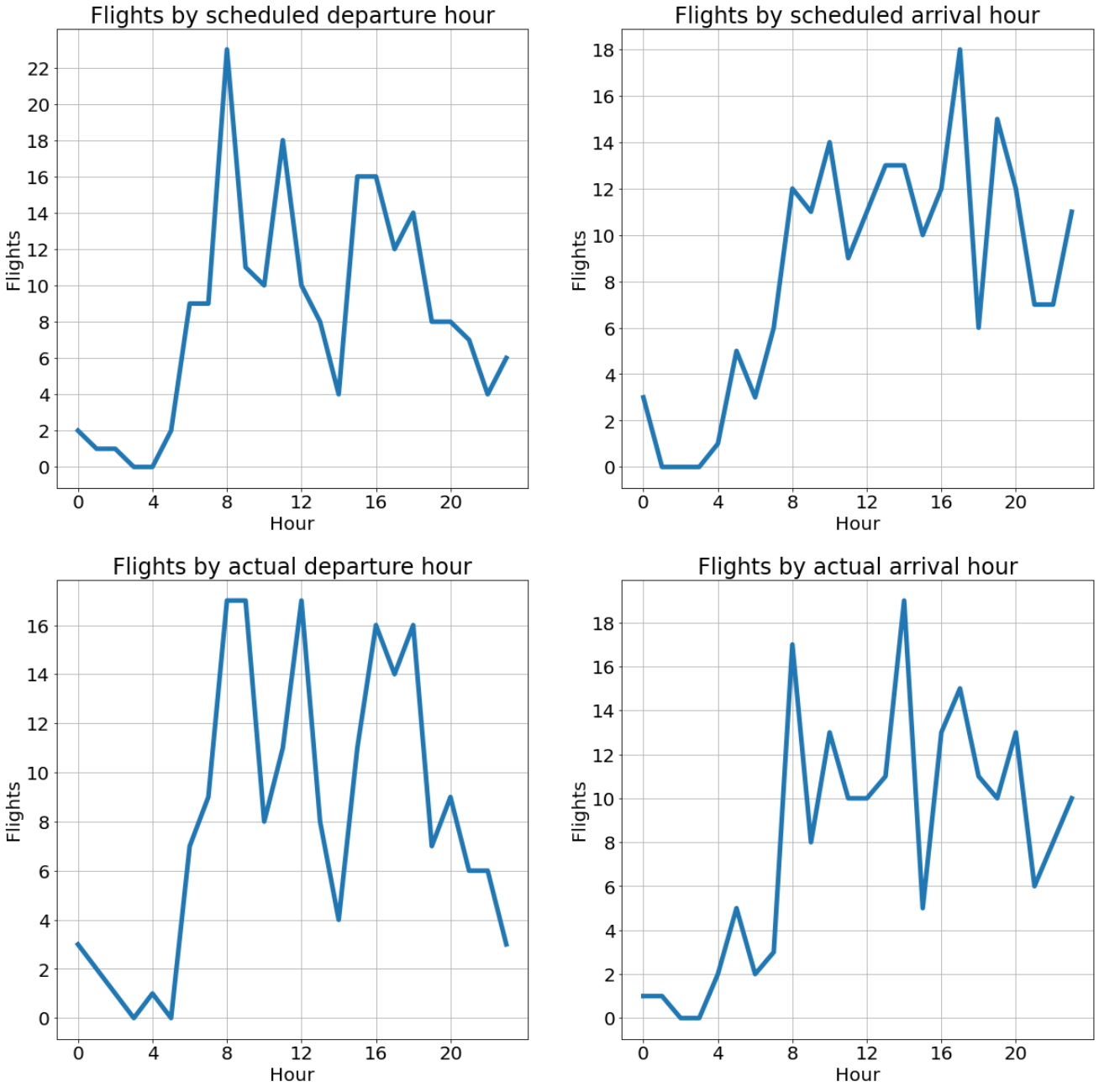
ax[1, 0].plot(actual_dep_hour['Hour'], actual_dep_hour['Count'], linewidth=5)
ax[1, 0].grid(True)
ax[1, 0].set_xticks(range(0,24,4))
ax[1, 0].set_xlabel('Hour')
ax[1, 0].set_yticks(np.arange(min(actual_dep_hour['Count']), max(actual_dep_h
ax[1, 0].set_ylabel('Flights')
ax[1, 0].set_title('Flights by actual departure hour')

ax[0, 1].plot(scheduled_arr_hour['Hour'], scheduled_arr_hour['Count'], linewi
ax[0, 1].grid(True)
ax[0, 1].set_xticks(range(0,24,4))
ax[0, 1].set_xlabel('Hour')
ax[0, 1].set_yticks(np.arange(min(scheduled_arr_hour['Count']), max(scheduled
ax[0, 1].set_ylabel('Flights')
ax[0, 1].set_title('Flights by scheduled arrival hour')

ax[1, 1].plot(actual_arr_hour['Hour'], actual_arr_hour['Count'], linewidth=5)
```

```
ax[1, 1].grid(True)
ax[1, 1].set_xticks(range(0,24,4))
ax[1, 1].set_xlabel('Hour')
ax[1, 1].set_yticks(np.arange(min(actual_arr_hour['Count']), max(actual_arr_h
ax[1, 1].set_ylabel('Flights')
ax[1, 1].set_title('Flights by actual arrival hour')
plt.savefig('figures/by_hour.jpg', bbox_inches='tight')
```

```
Morning flights (5a-12p): 82, 41%
Afternoon flights (12p-6p): 66, 33%
Evening flights (6p-11p): 41, 20%
Late nights flights (11p-5a): 10, 5%
```



ROUTES

In [211…

```
import pyproj
from geojson import LineString, Feature, FeatureCollection, dump
import geopy.distance


def get_hist(x):
    dct = {a: x.tolist().count(a) for a in x.tolist()}
    return ';'.join([str(list(dct.keys())[i]) + ',' + str(list(dct.values())[


def augment_routes(df):
    route_grouped = df.groupby('Sorted Route')
    df[['Class', 'Airline', 'Flight']] = df[['Class', 'Airline', 'Flight']].f
    df['route_date_string'] = route_grouped['Date'].transform(lambda x: ';'.j
    df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lamb
    df['route_airline_hist'] = route_grouped['Airline'].transform(get_hist)
    df['route_flight_string'] = route_grouped['Flight'].transform(lambda x: '
    df['route_origin_hist'] = route_grouped['Dep Airport'].transform(get_hist
    grouped = df.groupby('Sorted Route').first()[['Distance', 'Duration', 'Do
                                         'route_date_string', 'route_class_his
                                        ]]
    grouped['count'] = grouped['route_date_string'].apply(lambda x: len(x.spl

    grouped = grouped.reset_index()
    grouped['Dep IATA'] = grouped['Sorted Route'].apply(lambda x: x.split(' '
    grouped['Arr IATA'] = grouped['Sorted Route'].apply(lambda x: x.split(' '
    grouped = grouped.merge(airports[['IATA', 'Name', 'City', 'Country', 'Lat
    grouped = grouped.drop(columns='IATA').rename(columns={'Name': 'Dep Name'
    grouped = grouped.merge(airports[['IATA', 'Name', 'City', 'Country', 'Lat
    grouped = grouped.drop(columns='IATA').rename(columns={'Name': 'Arr Name'

    return grouped




def get_path(startlong, startlat, endlong, endlat):
    # calculate distance between points
    g = pyproj.Geod(ellps='WGS84')
    (az12, az21, dist) = g.inv(startlong, startlat, endlong, endlat)

    # calculate line string along path with segments <= 1 km
    lonlats = g.npts(startlong, startlat, endlong, endlat,
                     1 + int(dist / 5000))

    # npts doesn't include start/end points, so prepend/append them
    lonlats.insert(0, (startlong, startlat))
    lonlats.append((endlong, endlat))
```

```
    offset = 0
    for i in range(len(lonlats)-1):
        if lonlats[i][0] > 0 and lonlats[i+1][0] < 0 and lonlats[i+1][0] < -1
            offset = 360
        elif lonlats[i][0] < 0 and lonlats[i+1][0] > 0 and lonlats[i+1][0] >
            offset = -360
        lonlats[i+1] = (lonlats[i+1][0] + offset , lonlats[i+1][1])
#     print(len(lonlats))
    return LineString(lonlats)


def make_route_geojson(df, path):

    grouped = augment_routes(df)

    features = []
    for i, row in grouped.iterrows():
    #     lats = row['Sorted Lat'].split(';')
    #     longs = row['Sorted Long'].split(';')
        properties = properties = {'start_iata': row['Dep IATA'],
                                   'start_name': row['Dep Name'],
                                   'start_city_country': row['Dep City'] + ', ' +
                                   'end_iata': row['Arr IATA'],
                                   'end_name': row['Arr Name'],
                                   'end_city_country': row['Arr City'] + ', ' + ro
                                   'dist': row['Distance'],
                                   'dur': row['Duration'],
                                   'domint': row['Domestic/International'],
                                   'count': row['count'],
                                   'earliest_date': row['route_date_string'].split
                                   'latest_date': row['route_date_string'].split('
                                   'date_string': row['route_date_string'],
                                   'class_hist': row['route_class_hist'],
                                   'airline_hist': row['route_airline_hist'],
                                   'flight_string': row['route_flight_string'],
                                   'origin_hist': row['route_origin_hist']
                                  }
        features.append(Feature(geometry=get_path(row['Dep Long'], row['Dep L
                                                  row['Arr Long'], row['Arr L
                                    properties = properties))
    fc = FeatureCollection(features)

    with open(path, 'w') as f:
        dump(fc, f)
```

AIRPORTS AUGMENTED

In [212…

```
from geojson import Point, Feature, FeatureCollection, dump

def augment_airports(df):
```

```
df['Year'] = df['Date'].dt.year

dep_grouped = df.groupby('Dep Airport')
df['dep_dest_hist'] = dep_grouped['Arr Airport'].transform(get_hist)
df['dep_count'] = dep_grouped['Date'].transform(lambda v: v.shape[0])
df['dep_first'] = dep_grouped['Date'].transform(lambda v: min(v))
df['dep_last'] = dep_grouped['Date'].transform(lambda v: max(v))
df['dep_airline_hist'] = dep_grouped['Airline'].transform(get_hist)
df['dep_intdom_hist'] = dep_grouped['Domestic/International'].transform(g
df['dep_year_hist'] = dep_grouped['Year'].transform(get_hist)

arr_grouped = df.groupby('Arr Airport')
df['arr_dest_hist'] = arr_grouped['Dep Airport'].transform(get_hist)
df['arr_count'] = arr_grouped['Date'].transform(lambda v: v.shape[0])
df['arr_first'] = arr_grouped['Date'].transform(lambda v: min(v))
df['arr_last'] = arr_grouped['Date'].transform(lambda v: max(v))
df['arr_conn_count'] = arr_grouped['Arr Connect'].transform(lambda v: int
df['arr_airline_hist'] = arr_grouped['Airline'].transform(get_hist)
df['arr_intdom_hist'] = arr_grouped['Domestic/International'].transform(g
df['arr_year_hist'] = arr_grouped['Year'].transform(get_hist)

df['arr_conn_year_hist'] = df[df['Arr Connect'] == 1].groupby('Arr Airpor

df = df.drop(columns='arr_conn_year_hist').merge(df[['Arr Airport', 'arr_

deps = df.groupby('Dep Airport').first()[['Dep Name', 'Dep City', 'Dep Co
                                         'dep_dest_hist', 'dep_count', 'dep_fir
                                        ]].reset_index()
arrcons = df.groupby('Arr Airport').first()[['Arr Name', 'Arr City', 'Arr
                                            'arr_dest_hist', 'arr_count'
                                         'arr_conn_count', 'arr_conn_year_hist'
                                        ]].reset_index()
airports_aug = deps.merge(arrcons, left_on='Dep Airport', right_on='Arr A

def merge_names(row):
    for col in ['Airport', 'Name', 'City', 'Country']:
        row[col] = row['Dep '+ col] if type(row['Dep '+ col]) == str else
    for col in ['Lat', 'Long']:
        row[col] = row['Dep '+ col] if not np.isnan(row['Dep '+ col]) else
    return row


airports_aug = airports_aug.apply(merge_names, axis=1)
airports_aug = airports_aug.rename(columns={'Airport': 'IATA'})

airports_aug = airports_aug[['IATA', 'Name', 'City', 'Country', 'Lat', 'L
                             'dep_count', 'arr_count', 'arr_conn_count',
                             'dep_dest_hist', 'arr_dest_hist',
                             'dep_first', 'arr_first', 'dep_last', 'arr_l
                             'dep_airline_hist', 'arr_airline_hist',
                             'dep_intdom_hist', 'arr_intdom_hist',
                             'dep_year_hist', 'arr_year_hist', 'arr_conn_
                            ]]
```

```
    airports_aug['dep_count'] = airports_aug['dep_count'].fillna(0) - airport
    airports_aug['arr_count'] = airports_aug['arr_count'].fillna(0) - airport

    def subtract_hist(row):
        dep_hist = {int(x.split(',')[0]): int(x.split(',')[1]) for x in row['
        arr_hist = {int(x.split(',')[0]): int(x.split(',')[1]) for x in row['
        conn_hist = {int(x.split(',')[0]): int(x.split(',')[1]) for x in row[

        for year in conn_hist:
            if year in dep_hist:
                dep_hist[year] -= conn_hist[year]
            else:
                print(year, 'not in dep')
            if year in arr_hist:
                arr_hist[year] -= conn_hist[year]
            else:
                print(year, 'not in arr')

        row['dep_year_hist'] = ';'.join([str(x) + ',' + str(dep_hist[x]) for
        row['arr_year_hist'] = ';'.join([str(x) + ',' + str(arr_hist[x]) for
        full_year_hist = {}
        for key in dep_hist:
            full_year_hist[key] = full_year_hist[key] + dep_hist[key] if key
        for key in arr_hist:
            full_year_hist[key] = full_year_hist[key] + arr_hist[key] if key
        for key in conn_hist:
            full_year_hist[key] = full_year_hist[key] + conn_hist[key] if key
        row['full_year_hist'] = ';'.join([str(x) + ',' + str(full_year_hist[x
        return row

    airports_aug[['dep_year_hist', 'arr_year_hist', 'arr_conn_year_hist']] =
    airports_aug = airports_aug.apply(subtract_hist, axis=1)
    airports_aug['total'] = airports_aug['dep_count'].fillna(0) + airports_au
    airports_aug['first'] = airports_aug.apply(lambda row: min(row['dep_first
    airports_aug['last'] = airports_aug.apply(lambda row: min(row['dep_last']
    year_airports_aug.append(airports_aug)
    return airports_aug

def make_airport_geojson(df, path):
    airports_aug = augment_airports(df)
    for col in ['dep_first', 'arr_first', 'dep_last', 'arr_last', 'first', 'l
        airports_aug[col] = airports_aug[col].dt.strftime('%Y-%m-%d')
    airports_aug = airports_aug.fillna('')
    features = []
    for i, row in airports_aug.iterrows():
#         print(row.drop(['Lat', 'Long']).to_dict())
        features.append(Feature(geometry=Point((row['Long'], row['Lat'])), pr
    fc = FeatureCollection(features)
    with open(path, 'w') as f:
        dump(fc, f)
```

In [ ]:

```
#### MAKE ROUTES
year_airports_aug = [] # first one is all

make_route_geojson(df, ROOT_DIR + 'routes_all.geojson')
make_airport_geojson(df, ROOT_DIR + 'airports_all.geojson')

all_years = df['Date'].dt.year.unique().tolist()
first_month = min(df[df['Date'].dt.year == all_years[0]]['Date'].dt.month)
last_month = max(df[df['Date'].dt.year == all_years[-1]]['Date'].dt.month)

with open(ROOT_DIR + "month_range.txt", "w") as text_file:
    text_file.write(','.join(str(x) for x in all_years) + '\n' + str(first_mo

for year in all_years:
    make_route_geojson(df[df['Date'].dt.year == year], ROOT_DIR + 'routes_' +
    make_airport_geojson(df[df['Date'].dt.year == year], ROOT_DIR + 'airports

print('years done')

for year in all_years:
    print(year)
    for month in range(1, 13):
        if year == all_years[0] and month < first_month:
            continue
        if year == all_years[-1] and month > last_month:
            continue
        print('  ', month)
        simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.
        make_route_geojson(simp_df, ROOT_DIR + 'routes_cum_' + str(year) + '_
        make_airport_geojson(simp_df, ROOT_DIR + 'airports_cum_' + str(year)
```

```
/Users/alexanderguo/opt/anaconda3/lib/python3.8/site-packages/pandas/core/fram
e.py:3191: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  self[k1] = value[k2]
<ipython-input-211-373e90645454>:14: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['route_date_string'] = route_grouped['Date'].transform(lambda x: ';'.join
(str(a) for a in x))
<ipython-input-211-373e90645454>:15: 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: https://pandas.pydata.org/pandas-docs/st
```

```
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lambda
x: str(x.tolist().count('Economy')) + ',' + str(x.tolist().count('Business')))
<ipython-input-211-373e90645454>:16: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['route_airline_hist'] = route_grouped['Airline'].transform(get_hist)
<ipython-input-211-373e90645454>:17: 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: https://pandas.pydata.org/pandas-docs/st
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  df['route_flight_string'] = route_grouped['Flight'].transform(lambda x: ';'.
join(x))
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<ipython-input-212-3449acb59ab2>:12: SettingWithCopyWarning:
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able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_intdom_hist'] = dep_grouped['Domestic/International'].transform(get_
hist)
<ipython-input-212-3449acb59ab2>:13: SettingWithCopyWarning:
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  df['dep_year_hist'] = dep_grouped['Year'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:16: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:17: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:18: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:19: SettingWithCopyWarning:
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  df['arr_conn_count'] = arr_grouped['Arr Connect'].transform(lambda v: int(v.
sum())).astype('int')
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<ipython-input-212-3449acb59ab2>:25: SettingWithCopyWarning:
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  df['arr_conn_year_hist'] = df[df['Arr Connect'] == 1].groupby('Arr Airport')
['Year'].transform(get_hist)
/Users/alexanderguo/opt/anaconda3/lib/python3.8/site-packages/pandas/core/fram
e.py:3191: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
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<ipython-input-211-373e90645454>:14: SettingWithCopyWarning:
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(str(a) for a in x))
<ipython-input-211-373e90645454>:15: SettingWithCopyWarning:
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See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lambda
```

```
x: str(x.tolist().count('Economy')) + ',' + str(x.tolist().count('Business')))
<ipython-input-211-373e90645454>:16: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:25: SettingWithCopyWarning:
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['Year'].transform(get_hist)
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  df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lambda
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```
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  df['arr_airline_hist'] = arr_grouped['Airline'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:22: SettingWithCopyWarning:
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hist)
<ipython-input-212-3449acb59ab2>:23: SettingWithCopyWarning:
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able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_conn_year_hist'] = df[df['Arr Connect'] == 1].groupby('Arr Airport')
['Year'].transform(get_hist)
/Users/alexanderguo/opt/anaconda3/lib/python3.8/site-packages/pandas/core/fram
e.py:3191: SettingWithCopyWarning:
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able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lambda
x: str(x.tolist().count('Economy')) + ',' + str(x.tolist().count('Business')))
<ipython-input-211-373e90645454>:16: SettingWithCopyWarning:
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  df['route_flight_string'] = route_grouped['Flight'].transform(lambda x: ';'.
join(x))
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  df['route_origin_hist'] = route_grouped['Dep Airport'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:4: SettingWithCopyWarning:
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  df['Year'] = df['Date'].dt.year
<ipython-input-212-3449acb59ab2>:7: 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

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  df['dep_dest_hist'] = dep_grouped['Arr Airport'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:8: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
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  df['dep_count'] = dep_grouped['Date'].transform(lambda v: v.shape[0])
<ipython-input-212-3449acb59ab2>:9: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:11: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
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<ipython-input-212-3449acb59ab2>:12: SettingWithCopyWarning:
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hist)
<ipython-input-212-3449acb59ab2>:13: SettingWithCopyWarning:
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['Year'].transform(get_hist)
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hist)
<ipython-input-212-3449acb59ab2>:13: SettingWithCopyWarning:
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able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_year_hist'] = arr_grouped['Year'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:25: SettingWithCopyWarning:
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able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_conn_year_hist'] = df[df['Arr Connect'] == 1].groupby('Arr Airport')
['Year'].transform(get_hist)
/Users/alexanderguo/opt/anaconda3/lib/python3.8/site-packages/pandas/core/fram
e.py:3191: SettingWithCopyWarning:
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  self[k1] = value[k2]
<ipython-input-211-373e90645454>:14: SettingWithCopyWarning:
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  df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lambda
x: str(x.tolist().count('Economy')) + ',' + str(x.tolist().count('Business')))
<ipython-input-211-373e90645454>:16: SettingWithCopyWarning:
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See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/st
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  df['route_airline_hist'] = route_grouped['Airline'].transform(get_hist)
```

```
<ipython-input-211-373e90645454>:17: SettingWithCopyWarning:
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  df['route_flight_string'] = route_grouped['Flight'].transform(lambda x: ';'.
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<ipython-input-211-373e90645454>:18: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:4: SettingWithCopyWarning:
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  df['Year'] = df['Date'].dt.year
<ipython-input-212-3449acb59ab2>:7: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:8: SettingWithCopyWarning:
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  df['dep_count'] = dep_grouped['Date'].transform(lambda v: v.shape[0])
<ipython-input-212-3449acb59ab2>:9: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:10: SettingWithCopyWarning:
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  df['dep_last'] = dep_grouped['Date'].transform(lambda v: max(v))
<ipython-input-212-3449acb59ab2>:11: SettingWithCopyWarning:
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  df['dep_airline_hist'] = dep_grouped['Airline'].transform(get_hist)
```

```
<ipython-input-212-3449acb59ab2>:12: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_intdom_hist'] = dep_grouped['Domestic/International'].transform(get_
hist)
<ipython-input-212-3449acb59ab2>:13: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
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See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_year_hist'] = dep_grouped['Year'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:16: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:18: SettingWithCopyWarning:
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  df['arr_first'] = arr_grouped['Date'].transform(lambda v: min(v))
<ipython-input-212-3449acb59ab2>:19: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:20: SettingWithCopyWarning:
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able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_conn_count'] = arr_grouped['Arr Connect'].transform(lambda v: int(v.
sum())).astype('int')
<ipython-input-212-3449acb59ab2>:21: 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

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```

```
  df['arr_airline_hist'] = arr_grouped['Airline'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:22: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
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<ipython-input-212-3449acb59ab2>:25: SettingWithCopyWarning:
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  df['Year'] = df['Date'].dt.year
<ipython-input-212-3449acb59ab2>:7: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:8: SettingWithCopyWarning:
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  df['dep_count'] = dep_grouped['Date'].transform(lambda v: v.shape[0])
<ipython-input-212-3449acb59ab2>:9: SettingWithCopyWarning:
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<ipython-input-212-3449acb59ab2>:22: SettingWithCopyWarning:
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(str(a) for a in x))
<ipython-input-211-373e90645454>:15: SettingWithCopyWarning:
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  df['route_class_hist'] = route_grouped['Class'].transform(get_hist)#(lambda
x: str(x.tolist().count('Economy')) + ',' + str(x.tolist().count('Business')))
<ipython-input-211-373e90645454>:16: SettingWithCopyWarning:
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  df['route_airline_hist'] = route_grouped['Airline'].transform(get_hist)
<ipython-input-211-373e90645454>:17: SettingWithCopyWarning:
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  df['route_flight_string'] = route_grouped['Flight'].transform(lambda x: ';'.
join(x))
<ipython-input-211-373e90645454>:18: SettingWithCopyWarning:
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Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Year'] = df['Date'].dt.year
<ipython-input-212-3449acb59ab2>:7: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_dest_hist'] = dep_grouped['Arr Airport'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:8: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_count'] = dep_grouped['Date'].transform(lambda v: v.shape[0])
<ipython-input-212-3449acb59ab2>:9: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_first'] = dep_grouped['Date'].transform(lambda v: min(v))
<ipython-input-212-3449acb59ab2>:10: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_last'] = dep_grouped['Date'].transform(lambda v: max(v))
<ipython-input-212-3449acb59ab2>:11: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_airline_hist'] = dep_grouped['Airline'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:12: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_intdom_hist'] = dep_grouped['Domestic/International'].transform(get_
hist)
<ipython-input-212-3449acb59ab2>:13: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['dep_year_hist'] = dep_grouped['Year'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:16: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_dest_hist'] = arr_grouped['Dep Airport'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:17: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_count'] = arr_grouped['Date'].transform(lambda v: v.shape[0])
<ipython-input-212-3449acb59ab2>:18: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_first'] = arr_grouped['Date'].transform(lambda v: min(v))
<ipython-input-212-3449acb59ab2>:19: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_last'] = arr_grouped['Date'].transform(lambda v: max(v))
<ipython-input-212-3449acb59ab2>:20: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_conn_count'] = arr_grouped['Arr Connect'].transform(lambda v: int(v.
sum())).astype('int')
<ipython-input-212-3449acb59ab2>:21: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_airline_hist'] = arr_grouped['Airline'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:22: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_intdom_hist'] = arr_grouped['Domestic/International'].transform(get_
hist)
<ipython-input-212-3449acb59ab2>:23: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_year_hist'] = arr_grouped['Year'].transform(get_hist)
<ipython-input-212-3449acb59ab2>:25: 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: https://pandas.pydata.org/pandas-docs/st
able/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['arr_conn_year_hist'] = df[df['Arr Connect'] == 1].groupby('Arr Airport')
['Year'].transform(get_hist)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
years done
2015
   3
   4
   5

<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   6
   7
   8

<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
```

```
   9
   10
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   11
   12
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
2016
   1
   2
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   3
   4
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   5
   6
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   7
   8
```

```
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   9
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   10
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   11
   12
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
2017
   1
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   2
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   3
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   4
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   5
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   6
```

```
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   7
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   8
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   9
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   10
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   11
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   12
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
2018
   1
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   2
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   3
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   4
```

```
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   5
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   6
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   7
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   8
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   9
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   10
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   11
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   12
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
2019
   1
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   2
```

```
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   3
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   4
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   5
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   6
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
   7
<ipython-input-213-6b6beb3abdea>:28: UserWarning: Boolean Series key will be r
eindexed to match DataFrame index.
  simp_df = pd.concat([df[df['Date'].dt.year < year], df[df['Date'].dt.year ==
year][df['Date'].dt.month <= month]], ignore_index=True)
```

PRINTING

In [ ]:

```
def get_stats(df, airports_aug, year=None, ab=False):
    print(year)
    TOTAL_DIST = df['Distance'].sum()
    TOTAL_TIME = df['Duration'].sum()
    NUM_FLIGHTS = df['Date'].count()
    NUM_AIRLINES = df['Airline'].nunique()
    NUM_COUNTRIES = len(set(df['Dep Country'].tolist()) | set(df['Arr Country
    NUM_AIRPORTS = len(set(df['Dep Airport'].tolist()) | set(df['Arr Airport'

    dep_countries = df.groupby(['Dep Country', 'Dep Airport']).agg({'Date': '
    dep_countries.columns = ['Country', 'Airport', 'Departures']
    arr_countries = df.groupby(['Arr Country', 'Arr Airport']).agg({'Date': '
    arr_countries.columns = ['Country', 'Airport', 'Arrivals']
    countries = pd.merge(dep_countries, arr_countries, how='outer').fillna(0)
    countries['Total Dep/Arr'] = countries['Departures'] + countries['Arrival

    routes_sorted = df.groupby('Sorted Route').agg({'Date': 'count', 'Distanc
    routes_sorted.columns = ['Count', 'Total Distance', 'Duration']
```

```
airlines = df.groupby(['Airline']).agg({'Date': 'count', 'Distance': sum,
airlines.columns = ['Count', 'Total Distance', 'Duration']

dist_year = df.groupby(df['Date'].dt.year).agg({'Distance': sum, 'Date':
dist_year.columns = ['Distance', 'Flights', 'Duration']

dom_int = df.groupby('Domestic/International').agg({'Distance': sum, 'Dat
dom_int.columns = ['Distance', 'Flights', 'Duration']

clas = df.groupby('Class').agg({'Distance': sum, 'Date': 'count', 'Durati
clas.columns = ['Distance', 'Flights', 'Duration']

early_arrivals = df[df['Arr Delay'] < 0].shape[0]
on_time_arrivals = df[(df['Arr Delay'] >= 0) & (df['Arr Delay'] < 15)].sh
late_arrivals = df[(df['Arr Delay'] >= 15) & (df['Arr Delay'] < 60)].shap
really_late_arrivals = df[df['Arr Delay'] >= 60].shape[0]

morning_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 5) & (d
afternoon_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 12) &
evening_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 18) & (
late_night_flights = df[(df['Scheduled Dep Time (Local)'].dt.hour >= 23)

def get_time(minutes):
    return [int(minutes//60), int(minutes % 60)]

def get_time_str(minutes):
    if get_time(minutes)[0] == 0:
        return str(get_time(minutes)[1]) + 'min'
    else:
        return str(get_time(minutes)[0]) + 'h ' + str(get_time(minutes)[1


big_str = ''
if ab:
    big_str += '<h2><span class=\'bold\'>Alex\'s Flight Log (' + str(firs
else:
    big_str += '<h2><span class=\'bold\'>Alex\'s Flight Log (' + str(year

big_str += '<p>Total Distance Flown: <span class=\'bold\'>' + '{:,}'.form
big_str += '<br>Total Time in Air: <span class=\'bold\'>' + str(timedelta
big_str += '<br>Total Flights: <span class=\'bold\'>' + str(NUM_FLIGHTS)
big_str += '<br>Number of Airlines: <span class=\'bold\'>' + str(NUM_AIRL
big_str += ', Countries: <span class=\'bold\'>' + str(NUM_COUNTRIES) + '<
big_str += ', Airports: <span class=\'bold\'>' + str(NUM_AIRPORTS) + '</s
big_str += '<p>Longest interval between flights: <span class=\'bold\'>' +
big_str += '<br>Month with most flying: <span class=\'bold\'>'
big_str += str(a.sort_values('Flights', ascending=False).reset_index().lo
big_str += str(int(a.sort_values('Flights', ascending=False).reset_index(
big_str += get_time_str(a.sort_values('Flights', ascending=False).reset_i
big_str += str(a.sort_values('Duration', ascending=False).reset_index().l
big_str += str(int(a.sort_values('Duration', ascending=False).reset_index
big_str += get_time_str(a.sort_values('Duration', ascending=False).reset_
```

```
by_dist = df[df['Duration'] != 0.0].sort_values(by='Duration')
print(by_dist)
big_str += ('<p>Shortest flight: <span class=\'bold\'>' + by_dist.iloc[0]
            + ' (' + '{:,}'.format(by_dist.iloc[0]['Distance']).split('.'


by_dist2 = df.sort_values(by='Duration', ascending=False)
big_str += ('<br>Longest flight: <span class=\'bold\'>' + by_dist2.iloc[0
            + ' (' + '{:,}'.format(by_dist2.iloc[0]['Distance']).split('.

countries_list = countries.reset_index().groupby('Country').count().reset
country_airport = '<p>Airport distribution (top countries): '
for country, airports in countries_list[:3]:
    country_airport += '<span class=\'bold\'>' + country + '</span>: ' +
country_airport = country_airport[:-2]
big_str += country_airport + '\n'

# visited_airports
visited_list = airports_aug.sort_values(by='total', ascending=False)[['IA
visited_airports = '<br>Airports by total visits: '
for airport, total in visited_list[:3]:
    visited_airports += '<span class=\'bold\'>' + airport + '</span>: ' +
visited_airports = visited_airports[:-2]
big_str += visited_airports + '\n'

routes_list = routes_sorted.reset_index()[['Sorted Route', 'Count']].valu
top_routes = '<br>Top routes: '
for route, count in routes_list[:5]:
    top_routes += '<span class=\'bold\'>' + route.split(' ')[0] + '</span
top_routes = top_routes[:-2]
big_str += top_routes + '\n'

airlines_list = airlines.reset_index()[['Airline', 'Count']].values.tolis
top_airlines = '<br>Top airlines: '
for airline, count in airlines_list[:3]:
    top_airlines += '<span class=\'bold\'>' + airline + '</span>: ' + str
top_airlines = top_airlines[:-2]
big_str += top_airlines + '\n'

big_str += '<p>Early arrivals: <span class=\'bold\'>' + str(early_arrival
big_str += '<br>On-time arrivals (within 15min): <span class=\'bold\'>' +
big_str += '<br>Late arrivals (up to 1hr delay): <span class=\'bold\'>' +
big_str += '<br>Really late arrivals (>1hr delay): <span class=\'bold\'>'
big_str += '</p>\n'

big_str += '<p>Morning flights (5am-12p): <span class=\'bold\'>' + str(mo
big_str += '<br>Afternoon flights (12p-6p): <span class=\'bold\'>' + str(
big_str += '<br>Evening flights (6p-11p): <span class=\'bold\'>' + str(ev
big_str += '<br>Late night flights (11p-5a): <span class=\'bold\'>' + str
big_str += '</p>\n'

dom_int_list = dom_int.reset_index()[['Domestic/International', 'Distance
```

```
    domint = '<p>'
    for di, dist, count in dom_int_list:
        domint += '<span class=\'bold\'>' + di + '</span>: ' + '{:,}'.format(
    domint = domint[:-5] + '</p>'
    big_str += domint + '\n'

    class_list = clas.reset_index()[['Class', 'Distance', 'Flights']].values.
    class_str = '<p>'
    for c, dist, count in class_list:
        class_str += '<span class=\'bold\'>' + c + '</span>: ' + '{:,}'.forma
    class_str = class_str[:-5] + '</p>'
    big_str += class_str + '\n'

    if ab: # ind years don't need this
        print(dist_year.reset_index())
        years_list = dist_year.reset_index()[['Date', 'Distance', 'Flights',
        years = '<p>'
        for year, dist, count, dur in years_list:
            years += '<span class=\'bold\'>' + str(int(year)) + '</span>: ' +
        years = years[:-5] + '</p>'
        big_str += years + '\n'

#     print(big_str)
    return big_str

big_str = get_stats(df, year_airports_aug[0], ab=True)
with open(ROOT_DIR + "all_stats.txt", "w") as text_file:
    text_file.write(big_str)
for i, year in enumerate(all_years):
    big_str = get_stats(df[df['Date'].dt.year == year], year_airports_aug[i+1
    with open(ROOT_DIR + str(year) + "_stats.txt", "w") as text_file:
        text_file.write(big_str)
```

In [ ]: