TDI Challenge 2019 by Sungryong Hong.

> This notebook will show how I have solved the problems in *Section 1 and 2*.

1. NYPD Motor Vehicle Collision Data

In [1]:

```
# basic modules
import sys
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
#from scipy.spatial import cKDTree


# plot settings
plt.rc('font', family='serif')
plt.rc('font', serif='Times New Roman')
plt.rcParams.update({'font.size': 16})
plt.rcParams['mathtext.fontset'] = 'stix'
```

1.1 Read and Explore the data

In [2]:

```
# Read data
rawdf = pd.read_csv("./NYPD_Motor_Vehicle_Collisions.csv", low_memory=False)
```

In [3]:

```
rawdf.head(3)
```

Out[3]:

	DATE	TIME	BOROUGH	ZIP CODE	LATITUDE	LONGITUDE	LOCATION	ON STREET NAME	C ST
0	04/28/2019	0:00	BROOKLYN	11208	40.685050	-73.875950	(40.68505, -73.87595)	NaN	
1	04/28/2019	0:00	QUEENS	11419	40.690490	-73.816086	(40.69049, -73.816086)	103 AVENUE	S
2	04/28/2019	0:00	NaN	NaN	40.699955	-73.986820	(40.699955, -73.98682)	JAY STREET	S S

3 rows × 29 columns

In [4]:

```
rawdf.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1486228 entries, 0 to 1486227
Data columns (total 29 columns):
DATE                            1486228 non-null object
TIME                            1486228 non-null object
BOROUGH                         1041434 non-null object
ZIP CODE                        1041259 non-null object
LATITUDE                        1299800 non-null float64
LONGITUDE                       1299800 non-null float64
LOCATION                        1299800 non-null object
ON STREET NAME                  1200762 non-null object
CROSS STREET NAME               1010085 non-null object
OFF STREET NAME                 193313 non-null object
NUMBER OF PERSONS INJURED       1486211 non-null float64
NUMBER OF PERSONS KILLED        1486197 non-null float64
NUMBER OF PEDESTRIANS INJURED   1486228 non-null int64
NUMBER OF PEDESTRIANS KILLED    1486228 non-null int64
NUMBER OF CYCLIST INJURED       1486228 non-null int64
NUMBER OF CYCLIST KILLED        1486228 non-null int64
NUMBER OF MOTORIST INJURED      1486228 non-null int64
NUMBER OF MOTORIST KILLED       1486228 non-null int64
CONTRIBUTING FACTOR VEHICLE 1   1482376 non-null object
CONTRIBUTING FACTOR VEHICLE 2   1288405 non-null object
CONTRIBUTING FACTOR VEHICLE 3   95687 non-null object
CONTRIBUTING FACTOR VEHICLE 4   19874 non-null object
CONTRIBUTING FACTOR VEHICLE 5   5060 non-null object
UNIQUE KEY                      1486228 non-null int64
VEHICLE TYPE CODE 1             1481551 non-null object
VEHICLE TYPE CODE 2             1245846 non-null object
VEHICLE TYPE CODE 3             125163 non-null object
VEHICLE TYPE CODE 4             47740 non-null object
VEHICLE TYPE CODE 5             10177 non-null object
dtypes: float64(4), int64(7), object(18)
memory usage: 328.8+ MB
```

In [5]:

```
rawdf.columns.values
```

Out[5]:

```
array(['DATE', 'TIME', 'BOROUGH', 'ZIP CODE', 'LATITUDE', 'LONGITU
DE',
       'LOCATION', 'ON STREET NAME', 'CROSS STREET NAME',
       'OFF STREET NAME', 'NUMBER OF PERSONS INJURED',
       'NUMBER OF PERSONS KILLED', 'NUMBER OF PEDESTRIANS INJURED'
,
       'NUMBER OF PEDESTRIANS KILLED', 'NUMBER OF CYCLIST INJURED'
,
       'NUMBER OF CYCLIST KILLED', 'NUMBER OF MOTORIST INJURED',
       'NUMBER OF MOTORIST KILLED', 'CONTRIBUTING FACTOR VEHICLE 1
',
       'CONTRIBUTING FACTOR VEHICLE 2', 'CONTRIBUTING FACTOR VEHIC
LE 3',
       'CONTRIBUTING FACTOR VEHICLE 4', 'CONTRIBUTING FACTOR VEHIC
LE 5',
       'UNIQUE KEY', 'VEHICLE TYPE CODE 1', 'VEHICLE TYPE CODE 2',
       'VEHICLE TYPE CODE 3', 'VEHICLE TYPE CODE 4',
       'VEHICLE TYPE CODE 5'], dtype=object)
```

1.2 Get `timestamp` from `DATE` and `TIME`

Testing whether `str` works for the conversions

In [6]:

```
rawdf[:5].apply(lambda row: pd.to_datetime(str(row[0])+' '+str(row[1])) , axis
=1)
```

Out[6]:

```
0   2019-04-28 00:00:00
1   2019-04-28 00:00:00
2   2019-04-28 00:00:00
3   2019-04-28 00:01:00
4   2019-04-28 00:05:00
dtype: datetime64[ns]
```

Ok. Let's make a `datetime` column

In [7]:

```
%%time
rawdf['datetime'] = rawdf.apply(lambda row: pd.to_datetime(str(row[0])+' '+str
(row[1])) , axis=1)
```

```
CPU times: user 7min 10s, sys: 2.76 s, total: 7min 13s
Wall time: 7min 13s
```

> It takes longer than I thought.
>
> However, I will keep sticking to Pandas, not Spark's Dataframe, for easy and dirty calculations

In [29]:

```
rawdf['datetime'][:5]
```

Out[29]:

```
0   2019-04-28 00:00:00
1   2019-04-28 00:00:00
2   2019-04-28 00:00:00
3   2019-04-28 00:01:00
4   2019-04-28 00:05:00
Name: datetime, dtype: datetime64[ns]
```

> Let's save this raw dataframe as a parquet table for future conveinence. We can start with loading this table afterwards, not reading the csv.

In [13]:

```
import pyarrow as pa
import pyarrow.parquet as pq
```

In [14]:

```
pq.write_table(pa.Table.from_pandas(rawdf), 'rawNYPDdata.parquet.snappy', comp
ression='snappy')
#rawdf = pq.read_table('rawNYPDdata.parquet.snappy').to_pandas()
```

1.3 Take the data `datetime < 2019-01-01` and Solve the problems in Section 1

In [31]:

```
%%time
df = rawdf[rawdf.datetime < '2019-01-01']
```

```
CPU times: user 152 ms, sys: 84.9 ms, total: 237 ms
Wall time: 235 ms
```

In [32]:

```
len(df.index)
```

Out[32]:

```
1420242
```

In [33]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 1420242 entries, 121 to 1486227
Data columns (total 30 columns):
DATE                             1420242 non-null object
TIME                             1420242 non-null object
BOROUGH                          998752 non-null object
ZIP CODE                         998596 non-null object
LATITUDE                         1239143 non-null float64
LONGITUDE                        1239143 non-null float64
LOCATION                         1239143 non-null object
ON STREET NAME                   1150474 non-null object
CROSS STREET NAME                977241 non-null object
OFF STREET NAME                  177631 non-null object
NUMBER OF PERSONS INJURED        1420225 non-null float64
NUMBER OF PERSONS KILLED         1420211 non-null float64
NUMBER OF PEDESTRIANS INJURED    1420242 non-null int64
NUMBER OF PEDESTRIANS KILLED     1420242 non-null int64
NUMBER OF CYCLIST INJURED        1420242 non-null int64
NUMBER OF CYCLIST KILLED         1420242 non-null int64
NUMBER OF MOTORIST INJURED       1420242 non-null int64
NUMBER OF MOTORIST KILLED        1420242 non-null int64
CONTRIBUTING FACTOR VEHICLE 1    1416626 non-null object
CONTRIBUTING FACTOR VEHICLE 2    1233039 non-null object
CONTRIBUTING FACTOR VEHICLE 3    91441 non-null object
CONTRIBUTING FACTOR VEHICLE 4    18977 non-null object
CONTRIBUTING FACTOR VEHICLE 5    4830 non-null object
UNIQUE KEY                       1420242 non-null int64
VEHICLE TYPE CODE 1              1415995 non-null object
VEHICLE TYPE CODE 2              1193976 non-null object
VEHICLE TYPE CODE 3              121112 non-null object
VEHICLE TYPE CODE 4              46875 non-null object
VEHICLE TYPE CODE 5              9955 non-null object
datetime                         1420242 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(4), int64(7), object(18)
memory usage: 335.9+ MB
```

(Q) What is the total number of persons injured in the dataset (up to December 31, 2018?)

In [34]:

```
df['NUMBER OF PERSONS INJURED'][:5]
```

Out[34]:

```
121     1.0
564     0.0
7206    0.0
7473    0.0
7815    0.0
Name: NUMBER OF PERSONS INJURED, dtype: float64
```

In [35]:

```
df['NUMBER OF PERSONS INJURED'].sum()
```

Out[35]:

```
368034.0
```

(Q) What proportion of collisions in 2016 resulted in injury or death of a cyclist?

> It is kind of vague(?) what you are asking(?). I will calculate the ratio (proportion) of `cyclist-related` accidents in 2016 to `the total` accidents in 2016.

In [37]:

```
df2016 = df[(df.datetime >= '2016-01-01') & (df.datetime < '2017-01-01')]
```

In [41]:

```
totalAccident2016 = len(df2016.index)
```

In [42]:

```
totalAccident2016
```

Out[42]:

```
229788
```

In [43]:

```
dfcyclist2016 = df2016[(df2016['NUMBER OF CYCLIST INJURED'] > 0) | (df2016['NUMBER OF CYCLIST KILLED'] > 0)]
```

In [46]:

```
dfcyclist2016[['NUMBER OF CYCLIST INJURED','NUMBER OF CYCLIST KILLED']].describe()
```

Out[46]:

	NUMBER OF CYCLIST INJURED	NUMBER OF CYCLIST KILLED
count	4976.000000	4976.000000
mean	1.005627	0.004019
std	0.120169	0.063277
min	0.000000	0.000000
25%	1.000000	0.000000
50%	1.000000	0.000000
75%	1.000000	0.000000
max	3.000000	1.000000

In [48]:

```
len(dfcyclist2016.index)
```

Out[48]:

```
4976
```

In [49]:

```
print np.double(len(dfcyclist2016.index))/np.double(totalAccident2016)
```

```
0.021654742632339373
```

(Q) Brooklyn in BOROUGH

> What proportion of all collisions in 2016 occured in Brooklyn? Only consider entries with a non-null value for BOROUGH.

In [62]:

```
df2016.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 229788 entries, 515403 to 758247
Data columns (total 30 columns):
DATE                            229788 non-null object
TIME                            229788 non-null object
BOROUGH                         153289 non-null object
ZIP CODE                        153244 non-null object
LATITUDE                        192620 non-null float64
LONGITUDE                       192620 non-null float64
LOCATION                        192620 non-null object
ON STREET NAME                  176684 non-null object
CROSS STREET NAME               132004 non-null object
OFF STREET NAME                 47229 non-null object
NUMBER OF PERSONS INJURED       229787 non-null float64
NUMBER OF PERSONS KILLED        229787 non-null float64
NUMBER OF PEDESTRIANS INJURED   229788 non-null int64
NUMBER OF PEDESTRIANS KILLED    229788 non-null int64
NUMBER OF CYCLIST INJURED       229788 non-null int64
NUMBER OF CYCLIST KILLED        229788 non-null int64
NUMBER OF MOTORIST INJURED      229788 non-null int64
NUMBER OF MOTORIST KILLED       229788 non-null int64
CONTRIBUTING FACTOR VEHICLE 1   229075 non-null object
CONTRIBUTING FACTOR VEHICLE 2   197530 non-null object
CONTRIBUTING FACTOR VEHICLE 3   14833 non-null object
CONTRIBUTING FACTOR VEHICLE 4   3178 non-null object
CONTRIBUTING FACTOR VEHICLE 5   793 non-null object
UNIQUE KEY                      229788 non-null int64
VEHICLE TYPE CODE 1             229206 non-null object
VEHICLE TYPE CODE 2             188531 non-null object
VEHICLE TYPE CODE 3             41088 non-null object
VEHICLE TYPE CODE 4             25897 non-null object
VEHICLE TYPE CODE 5             5152 non-null object
datetime                        229788 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(4), int64(7), object(18)
memory usage: 54.3+ MB
```

In [60]:

```
len(df2016.index)
```

Out[60]:

```
229788
```

In [61]:

```
df2016['BOROUGH'].count()
```

Out[61]:

```
153289
```

In [63]:

```
grouped = df2016.groupby('BOROUGH')
```

In [64]:

```
grouped.groups.keys()
```

Out[64]:

```
['BRONX', 'BROOKLYN', 'STATEN ISLAND', 'MANHATTAN', 'QUEENS']
```

In [67]:

```
len(grouped.get_group('BROOKLYN'))
```

Out[67]:

```
47461
```

In [68]:

```
print 47461.0/153289.0
```

```
0.309617780793
```

(Q) The number of cars in accidents for each zip code in 2016

> Obtain the number of vehicles involved in each collision in 2016. Group the collisions by zip code and compute the sum of all vehicles involved in collisions in each zip code, then report the maximum of these values.

> Explore **vehicle**-related columns

In [51]:

```
df2016[['VEHICLE TYPE CODE 1','VEHICLE TYPE CODE 2','VEHICLE TYPE CODE 3',\
        'VEHICLE TYPE CODE 4','VEHICLE TYPE CODE 5']][:5]
```

Out[51]:

	VEHICLE TYPE CODE 1	VEHICLE TYPE CODE 2	VEHICLE TYPE CODE 3	VEHICLE TYPE CODE 4	VEHICLE TYPE CODE 5
515403	PASSENGER VEHICLE	NaN	NaN	NaN	NaN
515492	PICK-UP TRUCK	SPORT UTILITY / STATION WAGON	NaN	NaN	NaN
515538	PASSENGER VEHICLE	NaN	NaN	NaN	NaN
515584	AMBUL	NaN	NaN	NaN	NaN
515789	PASSENGER VEHICLE	NaN	NaN	NaN	NaN

In [52]:

```
df2016[['CONTRIBUTING FACTOR VEHICLE 1','CONTRIBUTING FACTOR VEHICLE 2','CONTR
IBUTING FACTOR VEHICLE 3',\
        'CONTRIBUTING FACTOR VEHICLE 4','CONTRIBUTING FACTOR VEHICLE 5']][:5]
```

Out[52]:

	CONTRIBUTING FACTOR VEHICLE 1	CONTRIBUTING FACTOR VEHICLE 2	CONTRIBUTING FACTOR VEHICLE 3	CONTRIBUTING FACTOR VEHICLE 4	CONTRIBUT FACT VEHICL
515403	Unspecified	NaN	NaN	NaN	I
515492	Unsafe Lane Changing	Unspecified	NaN	NaN	I
515538	Unspecified	NaN	NaN	NaN	I
515584	Unspecified	NaN	NaN	NaN	I
515789	Unspecified	NaN	NaN	NaN	I

Testing `.isnull()` and `notnull()`, and check whether `boolean` can be treated as `integer`

In [71]:

```
df2016['VEHICLE TYPE CODE 2'][:5].isnull()
```

Out[71]:

```
515403     True
515492    False
515538     True
515584     True
515789     True
Name: VEHICLE TYPE CODE 2, dtype: bool
```

In [72]:

```
df2016['VEHICLE TYPE CODE 2'][:5].isnull().sum()
```

Out[72]:

```
4
```

In [74]:

```
df2016['VEHICLE TYPE CODE 2'][:5].notnull()
```

Out[74]:

```
515403    False
515492     True
515538    False
515584    False
515789    False
Name: VEHICLE TYPE CODE 2, dtype: bool
```

In [75]:

```
df2016['VEHICLE TYPE CODE 2'][:5].notnull().sum()
```

Out[75]:

```
1
```

Ok. The below can count the number of vehicles in each accident

In [77]:

```
df2016[['VEHICLE TYPE CODE 1','VEHICLE TYPE CODE 2','VEHICLE TYPE CODE 3',\
        'VEHICLE TYPE CODE 4','VEHICLE TYPE CODE 5']][:5]\
    .apply(lambda row: row.notnull().sum(),axis=1)
```

Out[77]:

```
515403    1
515492    2
515538    1
515584    1
515789    1
dtype: int64
```

In [78]:

```
df2016['numVehicles'] = df2016[['VEHICLE TYPE CODE 1','VEHICLE TYPE CODE 2',\
                                'VEHICLE TYPE CODE 3','VEHICLE TYPE CODE 4',\
                                'VEHICLE TYPE CODE 5']]\
                        .apply(lambda row: row.notnull().sum(),axis=1)
```

```
/home/shong/anaconda2/lib/python2.7/site-packages/ipykernel_launch
er.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pan
das-docs/stable/indexing.html#indexing-view-versus-copy
  """Entry point for launching an IPython kernel.
```

In [80]:

```
df2016['numVehicles'].describe()
```

Out[80]:

```
count    229788.000000
mean          2.131852
std           0.893740
min           0.000000
25%           2.000000
50%           2.000000
75%           2.000000
max           5.000000
Name: numVehicles, dtype: float64
```

In [82]:

```
df2016.columns.values
```

Out[82]:

```
array(['DATE', 'TIME', 'BOROUGH', 'ZIP CODE', 'LATITUDE', 'LONGITU
DE',
       'LOCATION', 'ON STREET NAME', 'CROSS STREET NAME',
       'OFF STREET NAME', 'NUMBER OF PERSONS INJURED',
       'NUMBER OF PERSONS KILLED', 'NUMBER OF PEDESTRIANS INJURED'
,
       'NUMBER OF PEDESTRIANS KILLED', 'NUMBER OF CYCLIST INJURED'
,
       'NUMBER OF CYCLIST KILLED', 'NUMBER OF MOTORIST INJURED',
       'NUMBER OF MOTORIST KILLED', 'CONTRIBUTING FACTOR VEHICLE 1
',
       'CONTRIBUTING FACTOR VEHICLE 2', 'CONTRIBUTING FACTOR VEHIC
LE 3',
       'CONTRIBUTING FACTOR VEHICLE 4', 'CONTRIBUTING FACTOR VEHIC
LE 5',
       'UNIQUE KEY', 'VEHICLE TYPE CODE 1', 'VEHICLE TYPE CODE 2',
       'VEHICLE TYPE CODE 3', 'VEHICLE TYPE CODE 4',
       'VEHICLE TYPE CODE 5', 'datetime', 'numVehicles'], dtype=ob
ject)
```

In [86]:

```
# Pandas Series
psCrashes = df2016[['ZIP CODE','numVehicles']].groupby('ZIP CODE').sum()
```

In [91]:

```
psCrashes.sort_values('numVehicles',ascending=False).head(5)
```

Out[91]:

ZIP CODE	numVehicles
11207	5703
11101	4375
11234	4283
11434	4181
11203	4142

The answer is `5703` at `ZIP = 11207`

(Q) Linear Trend of the number of Car Crashes

> Consider the total number of collisions each year from 2013-2018. Is there an apparent trend? Fit a linear regression for the number of collisions per year and report its slope.

In [97]:

```
df.columns.values
```

Out[97]:

```
array(['DATE', 'TIME', 'BOROUGH', 'ZIP CODE', 'LATITUDE', 'LONGITU
DE',
       'LOCATION', 'ON STREET NAME', 'CROSS STREET NAME',
       'OFF STREET NAME', 'NUMBER OF PERSONS INJURED',
       'NUMBER OF PERSONS KILLED', 'NUMBER OF PEDESTRIANS INJURED'
,
       'NUMBER OF PEDESTRIANS KILLED', 'NUMBER OF CYCLIST INJURED'
,
       'NUMBER OF CYCLIST KILLED', 'NUMBER OF MOTORIST INJURED',
       'NUMBER OF MOTORIST KILLED', 'CONTRIBUTING FACTOR VEHICLE 1
',
       'CONTRIBUTING FACTOR VEHICLE 2', 'CONTRIBUTING FACTOR VEHIC
LE 3',
       'CONTRIBUTING FACTOR VEHICLE 4', 'CONTRIBUTING FACTOR VEHIC
LE 5',
       'UNIQUE KEY', 'VEHICLE TYPE CODE 1', 'VEHICLE TYPE CODE 2',
       'VEHICLE TYPE CODE 3', 'VEHICLE TYPE CODE 4',
       'VEHICLE TYPE CODE 5', 'datetime'], dtype=object)
```

In [98]:

```
df[:2].datetime.dt.year
```

Out[98]:

```
121    2018
564    2018
Name: datetime, dtype: int64
```

In [130]:

```
# Pandas Series : the number of accidents by year
psNumAccidents = df['datetime'].groupby(df.datetime.dt.year).count()
```

In [131]:

```
psNumAccidents
```

Out[131]:

```
datetime
2012    100541
2013    203729
2014    206030
2015    217692
2016    229788
2017    230997
2018    231465
Name: datetime, dtype: int64
```

In [132]:

```
psNumAccidents.index.values
```

Out[132]:

```
array([2012, 2013, 2014, 2015, 2016, 2017, 2018])
```

In [133]:

```
psNumAccidents.values
```

Out[133]:

```
array([100541, 203729, 206030, 217692, 229788, 230997, 231465])
```

> Oh.. from 2013 .., not 2012

In [134]:

```
psNumAccidents = psNumAccidents[1:]
```

In [135]:

```
psNumAccidents.index.values
```

Out[135]:

```
array([2013, 2014, 2015, 2016, 2017, 2018])
```

In [136]:

```
psNumAccidents.values
```

Out[136]:

```
array([203729, 206030, 217692, 229788, 230997, 231465])
```

a simple `scipy` package

In [137]:

```
from scipy import stats
```

In [138]:

```
slope, intercept, r_value, p_value, std_err =\
stats.linregress(np.double(psNumAccidents.index.values),np.double(psNumAcciden
ts.values))
```

In [139]:

```
[slope, intercept, r_value, p_value, std_err]
```

Out[139]:

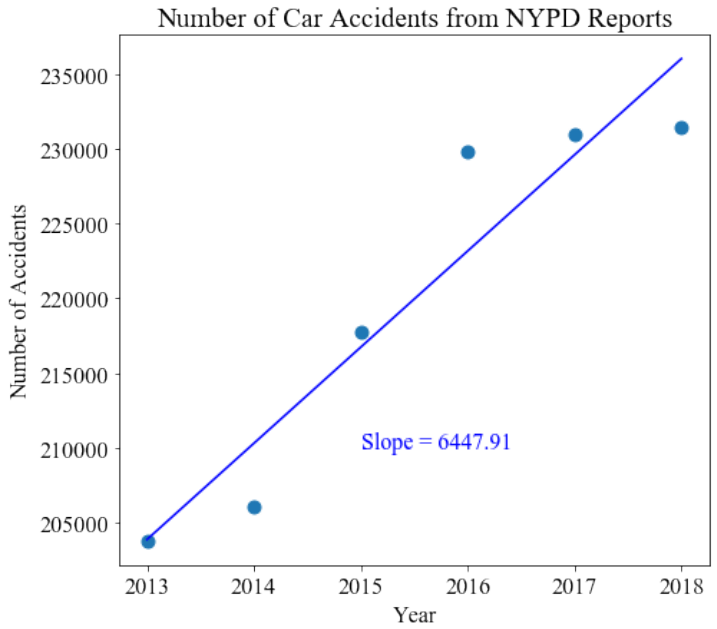
```
[6447.914285714285,
 -12775821.076190475,
 0.9457694166820132,
 0.004331689366288895,
 1107.3166194825742]
```

In [140]:

```
# model prediction
ymodel = 6447.914285714285 * np.double(psNumAccidents.index.values) -12775821.
076190475
```

In [141]:

```
# plot settings
plt.rc('font', family='serif')
plt.rc('font', serif='Times New Roman')
plt.rcParams.update({'font.size': 16})
plt.rcParams['mathtext.fontset'] = 'stix'


fig = plt.figure(figsize=(7,6.2))

#plt.axis([0,lenmax,0,1.0])
plt.title("Number of Car Accidents from NYPD Reports")
#plt.yscale('log')
#plt.xscale('log')
plt.ylabel(r'Number of Accidents')
plt.xlabel(r'Year')
plt.scatter(psNumAccidents.index.values,psNumAccidents.values,s=80)
plt.plot(psNumAccidents.index.values,ymodel,color='b')
plt.text(2015,210000,'Slope = 6447.91',color='b')


plt.tight_layout(pad=0.4, w_pad=0.5, h_pad=1.0)
#fig.savefig("car-accidents.eps")
plt.show()
```



(Q) Winter vs. Multple Car Crashes in 2017

> Do winter driving conditions lead to more multi-car collisions? Compute the rate of multi car collisions as the proportion of the number of collisions involving 3 or more cars to the total number of collisions for each month of 2017. Calculate the chi-square test statistic for testing whether a collision is more likely to involve 3 or more cars in January than in May

In [142]:

```
# sub-dateframe for 2017
df2017 = df[(df.datetime >= '2017-01-01') & (df.datetime < '2018-01-01')]
```

In [143]:

```
df2017.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 230997 entries, 297392 to 528484
Data columns (total 30 columns):
DATE                             230997 non-null object
TIME                             230997 non-null object
BOROUGH                          142946 non-null object
ZIP CODE                         142896 non-null object
LATITUDE                         217075 non-null float64
LONGITUDE                        217075 non-null float64
LOCATION                         217075 non-null object
ON STREET NAME                   177530 non-null object
CROSS STREET NAME                109967 non-null object
OFF STREET NAME                  53018 non-null object
NUMBER OF PERSONS INJURED        230986 non-null float64
NUMBER OF PERSONS KILLED         230981 non-null float64
NUMBER OF PEDESTRIANS INJURED    230997 non-null int64
NUMBER OF PEDESTRIANS KILLED     230997 non-null int64
NUMBER OF CYCLIST INJURED        230997 non-null int64
NUMBER OF CYCLIST KILLED         230997 non-null int64
NUMBER OF MOTORIST INJURED       230997 non-null int64
NUMBER OF MOTORIST KILLED        230997 non-null int64
CONTRIBUTING FACTOR VEHICLE 1    230311 non-null object
CONTRIBUTING FACTOR VEHICLE 2    197946 non-null object
CONTRIBUTING FACTOR VEHICLE 3    14520 non-null object
CONTRIBUTING FACTOR VEHICLE 4    3029 non-null object
CONTRIBUTING FACTOR VEHICLE 5    808 non-null object
UNIQUE KEY                       230997 non-null int64
VEHICLE TYPE CODE 1              229677 non-null object
VEHICLE TYPE CODE 2              166419 non-null object
VEHICLE TYPE CODE 3              18220 non-null object
VEHICLE TYPE CODE 4              8262 non-null object
VEHICLE TYPE CODE 5              1597 non-null object
datetime                         230997 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(4), int64(7), object(18)
memory usage: 54.6+ MB
```

In [144]:

```
%%time
# Count the nubmer of crashed vehicles in each accident, as we have done befor
e
df2017['numVehicles'] = df2017[['VEHICLE TYPE CODE 1','VEHICLE TYPE CODE 2',\
                                'VEHICLE TYPE CODE 3','VEHICLE TYPE CODE 4',
                                'VEHICLE TYPE CODE 5']]\
                           .apply(lambda row: row.notnull().sum(),axis=1)
```

```
CPU times: user 40.4 s, sys: 161 ms, total: 40.6 s
Wall time: 40.6 s

/home/shong/anaconda2/lib/python2.7/site-packages/ipykernel_launch
er.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pan
das-docs/stable/indexing.html#indexing-view-versus-copy
  after removing the cwd from sys.path.
```

> The running time is just OK. We do not need `PySpark` .

In [145]:

```
grouped2017 = df2017[['datetime','numVehicles']].groupby(df2017.datetime.dt.mo
nth)
```

In [147]:

```
grouped2017.groups.keys()
```

Out[147]:

```
[1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12]
```

In [148]:

```
dfJan = grouped2017.get_group(1)
```

In [149]:

```
dfJan.head(5)
```

Out[149]:

	datetime	numVehicles
506494	2017-01-28 13:10:00	2
507286	2017-01-26 18:10:00	1
507551	2017-01-26 19:30:00	2
508175	2017-01-25 03:50:00	2
508317	2017-01-24 09:15:00	2

In [150]:

```
dfMay = grouped2017.get_group(5)
```

In [151]:

```
[len(dfJan),len(dfMay)]
```

Out[151]:

```
[17551, 21012]
```

In [152]:

```
[len(dfJan[dfJan.numVehicles > 2]),len(dfMay[dfMay.numVehicles > 2])]
```

Out[152]:

```
[6212, 1136]
```

In [153]:

```
# the fraction of multiple (>2 or >=3) cars accidents to the total accidents
fracJan = 6212.0/17551.0
fracMay = 1136.0/21012.0
```

In [154]:

```
[fracJan, fracMay]
```

Out[154]:

```
[0.3539399464417982, 0.05406434418427565]
```

In [156]:

```
print "chisquare = ", ((fracJan-fracMay)**2/fracMay)
```

```
chisquare =  1.66330283269
```

Even from naive values (35% in Jan and 5% in May), **there are more multple-car-crashes in winter**. In my field of Astronomy and Astrophysics, we generally use the Kolmogorov Smirnov test.

In [158]:

```
from scipy.stats import ks_2samp
```

In [162]:

```
dval, pval = ks_2samp(np.double(dfJan.numVehicles.values), np.double(dfMay.num
Vehicles.values))
```

In [163]:

```
[dval, pval]
```

Out[163]:

```
[0.3040397849337455, 0.0]
```

what? numerically p = `zero` in the `float` precision? The patterns in multiple collions are statistically very very different between Jan and May.

(Q) Accidents related to Alcohol

For each borough, compute the number of accidents per capita involving alcohol in 2017. Report the highest rate among the 5 boroughs. Use populations as given by https://en.wikipedia.org/wiki/Demographics_of_New_York_City (https://en.wikipedia.org/wiki/Demographics_of_New_York_City).

In [203]:

```
# sub-dateframe for 2017
df2017 = df[(df.datetime >= '2017-01-01') & (df.datetime < '2018-01-01')]
```

In [204]:

```
df2017[['CONTRIBUTING FACTOR VEHICLE 1','CONTRIBUTING FACTOR VEHICLE 2','CONTR
IBUTING FACTOR VEHICLE 3',\
        'CONTRIBUTING FACTOR VEHICLE 4','CONTRIBUTING FACTOR VEHICLE 5']][:5]
```

Out[204]:

	CONTRIBUTING FACTOR VEHICLE 1	CONTRIBUTING FACTOR VEHICLE 2	CONTRIBUTING FACTOR VEHICLE 3	CONTRIBUTING FACTOR VEHICLE 4	CONTRIBUTIN FACTO VEHICLE
297392	Unspecified	Unspecified	NaN	NaN	Nal
297452	Unspecified	NaN	NaN	NaN	Nal
297453	Unspecified	NaN	NaN	NaN	Nal
297454	Reaction to Uninvolved Vehicle	Unspecified	NaN	NaN	Nal
297455	Driver Inexperience	Unspecified	NaN	NaN	Nal

Quick and Dirty implementation to find `alcohol` in *contributing factors*

In [205]:

```
df2017[['CONTRIBUTING FACTOR VEHICLE 1','CONTRIBUTING FACTOR VEHICLE 2',\
        'CONTRIBUTING FACTOR VEHICLE 3','CONTRIBUTING FACTOR VEHICLE 4',\
        'CONTRIBUTING FACTOR VEHICLE 5']][:5]\
    .apply(lambda row: (str(row[0])+str(row[1])+str(row[2])+str(row[3])+str(ro
w[4])).lower() ,axis=1)
```

Out[205]:

```
297392                     unspecifiedunspecifiednannannan
297452                             unspecifiednannannannan
297453                             unspecifiednannannannan
297454    reaction to uninvolved vehicleunspecifiednanna...
297455               driver inexperienceunspecifiednannannan
dtype: object
```

In [206]:

```
%%time
df2017['str_contribute'] =\
df2017[['CONTRIBUTING FACTOR VEHICLE 1','CONTRIBUTING FACTOR VEHICLE 2',\
        'CONTRIBUTING FACTOR VEHICLE 3','CONTRIBUTING FACTOR VEHICLE 4',\
        'CONTRIBUTING FACTOR VEHICLE 5']]\
    .apply(lambda row: (str(row[0])+str(row[1])+str(row[2])+str(row[3])+str(ro
w[4])).lower() ,axis=1)
```

```
CPU times: user 13.6 s, sys: 104 ms, total: 13.7 s
Wall time: 13.7 s

/home/shong/anaconda2/lib/python2.7/site-packages/ipykernel_launch
er.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pan
das-docs/stable/indexing.html#indexing-view-versus-copy
  """Entry point for launching an IPython kernel.
```

In [207]:

```
df2017['str_contribute'][:10]
```

Out[207]:

```
297392                       unspecifiedunspecifiednannannan
297452                              unspecifiednannannannan
297453                              unspecifiednannannannan
297454    reaction to uninvolved vehicleunspecifiednanna...
297455               driver inexperienceunspecifiednannannan
297456                       unspecifiedunspecifiednannannan
297457                              unspecifiednannannannan
297458    passing or lane usage improperoutside car dist...
297459                       unspecifiedunspecifiednannannan
297460                              unspecifiednannannannan
Name: str_contribute, dtype: object
```

In [208]:

```
df2017.columns.values
```

Out[208]:

```
array(['DATE', 'TIME', 'BOROUGH', 'ZIP CODE', 'LATITUDE', 'LONGITU
DE',
       'LOCATION', 'ON STREET NAME', 'CROSS STREET NAME',
       'OFF STREET NAME', 'NUMBER OF PERSONS INJURED',
       'NUMBER OF PERSONS KILLED', 'NUMBER OF PEDESTRIANS INJURED'
,
       'NUMBER OF PEDESTRIANS KILLED', 'NUMBER OF CYCLIST INJURED'
,
       'NUMBER OF CYCLIST KILLED', 'NUMBER OF MOTORIST INJURED',
       'NUMBER OF MOTORIST KILLED', 'CONTRIBUTING FACTOR VEHICLE 1
',
       'CONTRIBUTING FACTOR VEHICLE 2', 'CONTRIBUTING FACTOR VEHIC
LE 3',
       'CONTRIBUTING FACTOR VEHICLE 4', 'CONTRIBUTING FACTOR VEHIC
LE 5',
       'UNIQUE KEY', 'VEHICLE TYPE CODE 1', 'VEHICLE TYPE CODE 2',
       'VEHICLE TYPE CODE 3', 'VEHICLE TYPE CODE 4',
       'VEHICLE TYPE CODE 5', 'datetime', 'str_contribute'], dtype
=object)
```

In [211]:

```
df2017[['str_contribute']][:10].apply(lambda row: row[0].find('pecified'), axi
s=1)
```

Out[211]:

```
297392     3
297452     3
297453     3
297454    33
297455    22
297456     3
297457     3
297458    -1
297459     3
297460     3
dtype: int64
```

In [213]:

```
%%time
df2017['flag_alcohol'] =\
df2017[['str_contribute']].apply(lambda row: row[0].find('alcohol'), axis=1)
```

```
CPU times: user 3.66 s, sys: 32.5 ms, total: 3.7 s
Wall time: 3.69 s

/home/shong/anaconda2/lib/python2.7/site-packages/ipykernel_launch
er.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pan
das-docs/stable/indexing.html#indexing-view-versus-copy
  """Entry point for launching an IPython kernel.
```

In [214]:

```
len(df2017[df2017.flag_alcohol > -1])
```

Out[214]:

```
2675
```

In [218]:

```
dfAlcohol = df2017[df2017.flag_alcohol > -1]
```

In [219]:

```
groupedAlcohol = dfAlcohol.groupby('BOROUGH')
```

In [220]:

```
groupedAlcohol.groups.keys()
```

Out[220]:

```
['BRONX', 'BROOKLYN', 'STATEN ISLAND', 'MANHATTAN', 'QUEENS']
```

In [223]:

```
numAlcoholAcc =\
np.double(\
[len(groupedAlcohol.get_group('BRONX')),\
 len(groupedAlcohol.get_group('BROOKLYN')),\
 len(groupedAlcohol.get_group('STATEN ISLAND')),\
 len(groupedAlcohol.get_group('MANHATTAN')),\
 len(groupedAlcohol.get_group('QUEENS'))])
```

In [224]:

```
numAlcoholAcc
```

Out[224]:

```
array([274., 602., 100., 259., 512.])
```

In [225]:

```
# number of populations 2017 from wikipedia
numPop = np.double([1471160.0, 2648771.0, 479458.0, 1664727.0, 2358582.0])
```

In [228]:

```
numAlcoholAcc/numPop
```

Out[228]:

```
array([0.00018625, 0.00022728, 0.00020857, 0.00015558, 0.00021708]
)
```

In [229]:

```
(numAlcoholAcc/numPop).max()
```

Out[229]:

```
0.00022727521556223623
```

> 0.00022727521556223623 for 'BROOKLYN'

(Q) The spatial density of car accidents in 2017

> We can use collision locations to estimate the areas of the zip code regions. Represent each as an ellipse with semi-axes given by a single standard deviation of the longitude and latitude. For collisions in 2017, estimate the number of collisions per square kilometer of each zip code region. Considering zipcodes with at least 1000 collisions, report the greatest value for collisions per square kilometer. Note: Some entries may have invalid or incorrect (latitude, longitude) coordinates. Drop any values that are invalid or seem unreasonable for New York City.

In [230]:

```
# reassign the 2017 dataframe
df2017 = df[(df.datetime >= '2017-01-01') & (df.datetime < '2018-01-01')]
```

In [231]:

```
df2017.columns.values
```

Out[231]:

```
array(['DATE', 'TIME', 'BOROUGH', 'ZIP CODE', 'LATITUDE', 'LONGITU
DE',
       'LOCATION', 'ON STREET NAME', 'CROSS STREET NAME',
       'OFF STREET NAME', 'NUMBER OF PERSONS INJURED',
       'NUMBER OF PERSONS KILLED', 'NUMBER OF PEDESTRIANS INJURED'
,
       'NUMBER OF PEDESTRIANS KILLED', 'NUMBER OF CYCLIST INJURED'
,
       'NUMBER OF CYCLIST KILLED', 'NUMBER OF MOTORIST INJURED',
       'NUMBER OF MOTORIST KILLED', 'CONTRIBUTING FACTOR VEHICLE 1
',
       'CONTRIBUTING FACTOR VEHICLE 2', 'CONTRIBUTING FACTOR VEHIC
LE 3',
       'CONTRIBUTING FACTOR VEHICLE 4', 'CONTRIBUTING FACTOR VEHIC
LE 5',
       'UNIQUE KEY', 'VEHICLE TYPE CODE 1', 'VEHICLE TYPE CODE 2',
       'VEHICLE TYPE CODE 3', 'VEHICLE TYPE CODE 4',
       'VEHICLE TYPE CODE 5', 'datetime'], dtype=object)
```

In [232]:

```
df2017[['LONGITUDE','LATITUDE']].describe()
```

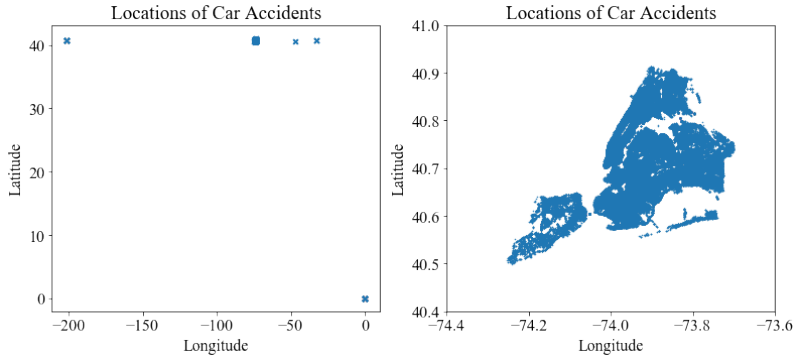
Out[232]:

	LONGITUDE	LATITUDE
count	217075.000000	217075.000000
mean	-73.919369	40.707421
std	2.536927	0.842007
min	-201.237060	0.000000
25%	-73.976000	40.667934
50%	-73.927284	40.722286
75%	-73.865405	40.771656
max	0.000000	41.126150

Plot the spatial positions and see how many points have abnormal positions

In [249]:

```
# plot settings
plt.rc('font', family='serif')
plt.rc('font', serif='Times New Roman')
plt.rcParams.update({'font.size': 16})
plt.rcParams['mathtext.fontset'] = 'stix'


fig = plt.figure(figsize=(11,5))


plt.subplot(121)
plt.title("Locations of Car Accidents")
#plt.axis([0,lenmax,0,1.0])
#plt.yscale('log')
#plt.xscale('log')
plt.ylabel(r'Latitude')
plt.xlabel(r'Longitude')
plt.scatter(df2017['LONGITUDE'].values,df2017['LATITUDE'].values,marker='x',s=
20)


plt.subplot(122)
plt.title("Locations of Car Accidents")
plt.axis([-74.4,-73.6,40.4,41])
#plt.yscale('log')
#plt.xscale('log')
plt.ylabel(r'Latitude')
plt.xlabel(r'Longitude')
plt.scatter(df2017['LONGITUDE'].values,df2017['LATITUDE'].values,marker='.',s=
1)
#plt.plot(psNumAccidents.index.values,ymodel,color='b')
#plt.text(2015,210000,'Slope = 6447.91',color='b')



plt.tight_layout(pad=0.4, w_pad=0.5, h_pad=1.0)
#fig.savefig("accidents-loccations.eps")
plt.show()
```



In [253]:

```
locdf =\
df2017[(df2017.LONGITUDE > -74.4) & (df2017.LONGITUDE < -73.6)\
       & (df2017.LATITUDE < 41.0) & (df2017.LATITUDE > 40.4)]
```

In [254]:

```
locdf[['LONGITUDE','LATITUDE']].describe()
```

Out[254]:

	LONGITUDE	LATITUDE
count	216908.000000	216908.000000
mean	-73.921092	40.724671
std	0.088014	0.079814
min	-74.253006	40.499310
25%	-73.975980	40.667976
50%	-73.927320	40.722305
75%	-73.865470	40.771748
max	-73.700584	40.912884

Now, all coordinates are in sanity.

In [255]:

```
locdf.columns.values
```

Out[255]:

```
array(['DATE', 'TIME', 'BOROUGH', 'ZIP CODE', 'LATITUDE', 'LONGITU
DE',
       'LOCATION', 'ON STREET NAME', 'CROSS STREET NAME',
       'OFF STREET NAME', 'NUMBER OF PERSONS INJURED',
       'NUMBER OF PERSONS KILLED', 'NUMBER OF PEDESTRIANS INJURED'
,
       'NUMBER OF PEDESTRIANS KILLED', 'NUMBER OF CYCLIST INJURED'
,
       'NUMBER OF CYCLIST KILLED', 'NUMBER OF MOTORIST INJURED',
       'NUMBER OF MOTORIST KILLED', 'CONTRIBUTING FACTOR VEHICLE 1
',
       'CONTRIBUTING FACTOR VEHICLE 2', 'CONTRIBUTING FACTOR VEHIC
LE 3',
       'CONTRIBUTING FACTOR VEHICLE 4', 'CONTRIBUTING FACTOR VEHIC
LE 5',
       'UNIQUE KEY', 'VEHICLE TYPE CODE 1', 'VEHICLE TYPE CODE 2',
       'VEHICLE TYPE CODE 3', 'VEHICLE TYPE CODE 4',
       'VEHICLE TYPE CODE 5', 'datetime'], dtype=object)
```

In [256]:

```
locgroup = locdf[['ZIP CODE', 'LATITUDE', 'LONGITUDE','datetime']].groupby('ZI
P CODE')
```

In [258]:

```
locgroup.groups.keys()[:5]
```

Out[258]:

```
['10065', '10069', '10012', '10453', '10452']
```

In [261]:

```
locgroup.get_group('10065').info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 796 entries, 297519 to 528177
Data columns (total 4 columns):
ZIP CODE      796 non-null object
LATITUDE      796 non-null float64
LONGITUDE     796 non-null float64
datetime      796 non-null datetime64[ns]
dtypes: datetime64[ns](1), float64(2), object(1)
memory usage: 31.1+ KB
```

In [286]:

```
locresult = pd.DataFrame(locgroup.datetime.count())
```

In [287]:

```
locresult.columns=['total']
```

In [288]:

```
locresult[:5]
```

Out[288]:

ZIP CODE	total
10000	73
10001	1656
10002	1607
10003	922
10004	200

In [289]:

```
locresult['stdlon'] = locgroup['LONGITUDE'].std().values
```

In [291]:

```
locresult['stdlat'] = locgroup['LATITUDE'].std().values
```

In [292]:

```
locresult.head(3)
```

Out[292]:

ZIP CODE	total	stdlon	stdlat
10000	73	0.005024	0.006955
10001	1656	0.005335	0.003272
10002	1607	0.006887	0.004739

In [306]:

```
locresult = locresult[locresult.total > 999]
```

In [307]:

```
locresult.head(3)
```

Out[307]:

ZIP CODE	total	stdlon	stdlat
10001	1656	0.005335	0.003272
10002	1607	0.006887	0.004739
10011	1113	0.004514	0.004031

I assume: `Earth Radius = 6,371 km`.

Spatial distance from Δ_{lat} = Radius $\times \Delta_{lat}$

Spatial distance from Δ_{lon} = Radius $\times \cos(lat_0) \times \Delta_{lon}$. We use $lat_0 = 40.724671$ (deg). From Degree to Radian, `degtorad = np.pi / 180.`

In [308]:

```
degtorad = np.pi / 180.
```

In [309]:

```
earthR = 6371.0
```

In [310]:

```
locresult[:5].apply(lambda row: earthR*row[2]*degtorad,axis=1)
```

Out[310]:

```
ZIP CODE
10001    0.363816
10002    0.526944
10011    0.448175
10013    0.305264
10016    0.362845
dtype: float64
```

In [311]:

```
locresult[:5].apply(lambda row: earthR*np.cos(40.724671*degtorad)*row[1]*degto
rad,axis=1)
```

Out[311]:

```
ZIP CODE
10001    0.449613
10002    0.580401
10011    0.380415
10013    0.366885
10016    0.335175
dtype: float64
```

In [312]:

```
locresult[:5].apply(lambda row: np.double(row[0])/\
                    (earthR*np.cos(40.724671*degtorad)*row[1]*degtorad\
                     *earthR*row[2]*degtorad*np.pi),axis=1)
```

Out[312]:

```
ZIP CODE
10001    3222.475593
10002    1672.529772
10011    2077.974268
10013    4280.260521
10016    3910.284091
dtype: float64
```

In [313]:

```
# we can optimize the redundant calculations, earthR*earthR*np.pi to a single
number.
# But, since we have only a small number of rows, let's do it without thinking
about any optimization of computing.
locresult['densityAccidents'] = \
locresult.apply(lambda row:\
                np.double(row[0])/\
                (np.pi*earthR*np.cos(40.724671*degtorad)*row[1]*degtorad*earth
R*row[2]*degtorad),axis=1)
```

In [315]:

```
locresult.sort_values('densityAccidents',ascending=False).head(10)
```

Out[315]:

ZIP CODE	total	stdlon	stdlat	densityAccidents
10022	1383	0.004003	0.002289	5126.768648
10036	1638	0.005027	0.002277	4861.222495
10013	1506	0.004354	0.002745	4280.260521
10016	1494	0.003977	0.003263	3910.284091
10001	1656	0.005335	0.003272	3222.475593
10018	1384	0.008062	0.002746	2123.704515
10011	1113	0.004514	0.004031	2077.974268
10459	1028	0.003992	0.004504	1941.882641
11226	1864	0.005391	0.006218	1888.913996
10019	1585	0.007031	0.004447	1722.160671

The answer is `5126.768648` for `ZIP = 10022`