KFold

August 1, 2019

In [1]:
```
import warnings
warnings.filterwarnings("ignore")
from matplotlib import pyplot as plt
#from sklearn import datasets, linear_model
from sklearn.linear_model import LinearRegression
import pandas as pd
from sklearn.model_selection import KFold, train_test_split
from sklearn.preprocessing import MinMaxScaler
from sklearn.svm import SVR
import numpy as np

from sklearn.cross_validation import cross_val_score, cross_val_predict
from sklearn import metrics
```

```
/opt/conda/lib/python3.6/site-packages/sklearn/cross_validation.py:41: DeprecationWarning: This
  "This module will be removed in 0.20.", DeprecationWarning)
```

In [2]:
```
def change_month(month):
    month = month.lower()

    month = month.replace('jan','1')
    month = month.replace('feb','2')
    month = month.replace('mar','3')
    month = month.replace('apr','4')
    month = month.replace('may','5')
    month = month.replace('jun','6')
    month = month.replace('jul','7')
    month = month.replace('aug','8')
    month = month.replace('sep','9')
    month = month.replace('oct','10')
    month = month.replace('nov','11')
    month = month.replace('dec','12')

    return month

def change_day(day):
    day = day.lower()
```

```
        day = day.replace('mon','1')
        day = day.replace('tue','2')
        day = day.replace('wed','3')
        day = day.replace('thu','4')
        day = day.replace('fri','5')
        day = day.replace('sat','6')
        day = day.replace('sun','7')

        return day
```

```
In [3]: df = pd.read_csv('forestfires.csv')
        # Get names of indexes for which column Age has value 30
        indexNames = df[ df['area'] <= 0].index

        # Delete these row indexes from dataFrame
        df.drop(indexNames , inplace=True)
        indexNames = df[df['area'] >400].index
        df.drop(indexNames,inplace=True)

        df['month'] = df['month'].apply(change_month)
        df['day'] = df['day'].apply(change_day)

        Y = df['area'].values
        X1 = df['FFMC'].values
        X2 = df['DMC'].values
        X3 = df['DC'].values
        X4 = df['ISI'].values
        X5 = df['temp'].values
        X6 = df['RH'].values
        X7 = df['wind'].values
        X8 = df['rain'].values

        #Create combined X matrix, which will be used to predict Price
        ones = np.ones((268,1))
        X_all = np.column_stack((ones,X1,X2,X3,X4,X5,X6,X7,X8))
        lm = LinearRegression()
        lm.fit(X_all, Y)
```

```
Out[3]: LinearRegression(copy_X=True, fit_intercept=True, n_jobs=1, normalize=False)
```

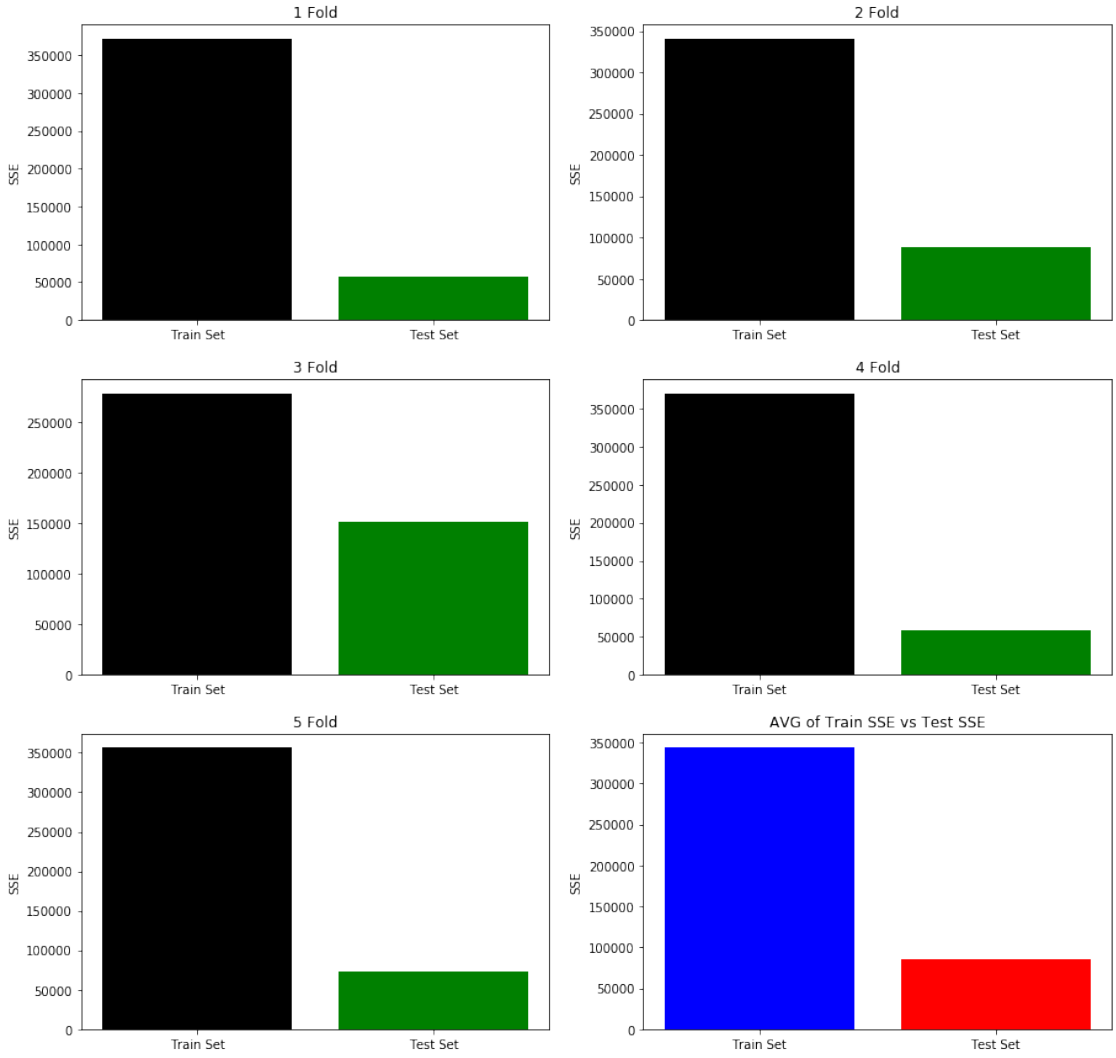
1 Only Ones Column M0 (Null Hypothesis)

```
In [4]: from sklearn.model_selection import KFold # import KFold
        X =  ones
        scaler = MinMaxScaler(feature_range=(0,1))
        X = scaler.fit_transform(X)
```

```
        kf = KFold(n_splits=5,shuffle=True) # Define the split - into 2 folds
        k_amount = kf.get_n_splits(X) # returns the number of splitting iterations in the cros
```

In [5]:
```
        fig, axes = plt.subplots(3, 2,figsize=(15,15))
        plot =[axes[0,0],axes[0,1],axes[1,0],axes[1,1],axes[2,0],axes[2,1]]
        iter_plot = 0
        total_train_SSE = 0
        total_test_SSE = 0
        total_w = 0
        for train_index, test_index in kf.split(X):
            X_train, X_test = X[train_index], X[test_index]
            Y_train, Y_test = Y[train_index], Y[test_index]
            #Find the weight by using train set
            w_train = np.linalg.lstsq(X_train,Y_train)[0]
            total_w = total_w+w_train

            #Predict the price with train and test set
            pred_train = np.dot(X_train,w_train)
            pred_test = np.dot(X_test,w_train)

            #Calculate SSE for training set and Test set
            train_SSE = sum((pred_train-Y_train)**2)
            test_SSE = sum((pred_test-Y_test)**2)
            total_train_SSE = total_train_SSE + train_SSE
            total_test_SSE = total_test_SSE + test_SSE
            plot[iter_plot].set_title(str(iter_plot+1)+' Fold')
            plot[iter_plot].bar('Train Set',train_SSE, color='k')
            plot[iter_plot].bar('Test Set',test_SSE, color='g')
            plot[iter_plot].set_ylabel('SSE')
            iter_plot = iter_plot+1

        avg_train_SSE = total_train_SSE/k_amount
        avg_test_SSE = total_test_SSE/k_amount
        avg_w = total_w/k_amount
        plot[iter_plot].set_title('AVG of Train SSE vs Test SSE')
        plot[iter_plot].bar('Train Set',avg_train_SSE, color='b')
        plot[iter_plot].bar('Test Set',avg_test_SSE, color='r')
        plot[iter_plot].set_ylabel('SSE')
        print('AVG Train SSE: ',avg_train_SSE,' AVG Test SSE: ',avg_test_SSE)
        print()
        print("Model M0: Area = {:.2f}".format(float(avg_w[0])))
```

```
AVG Train SSE:  343464.98904  AVG Test SSE:  85866.24726

Model M0: Area = 0.00
```

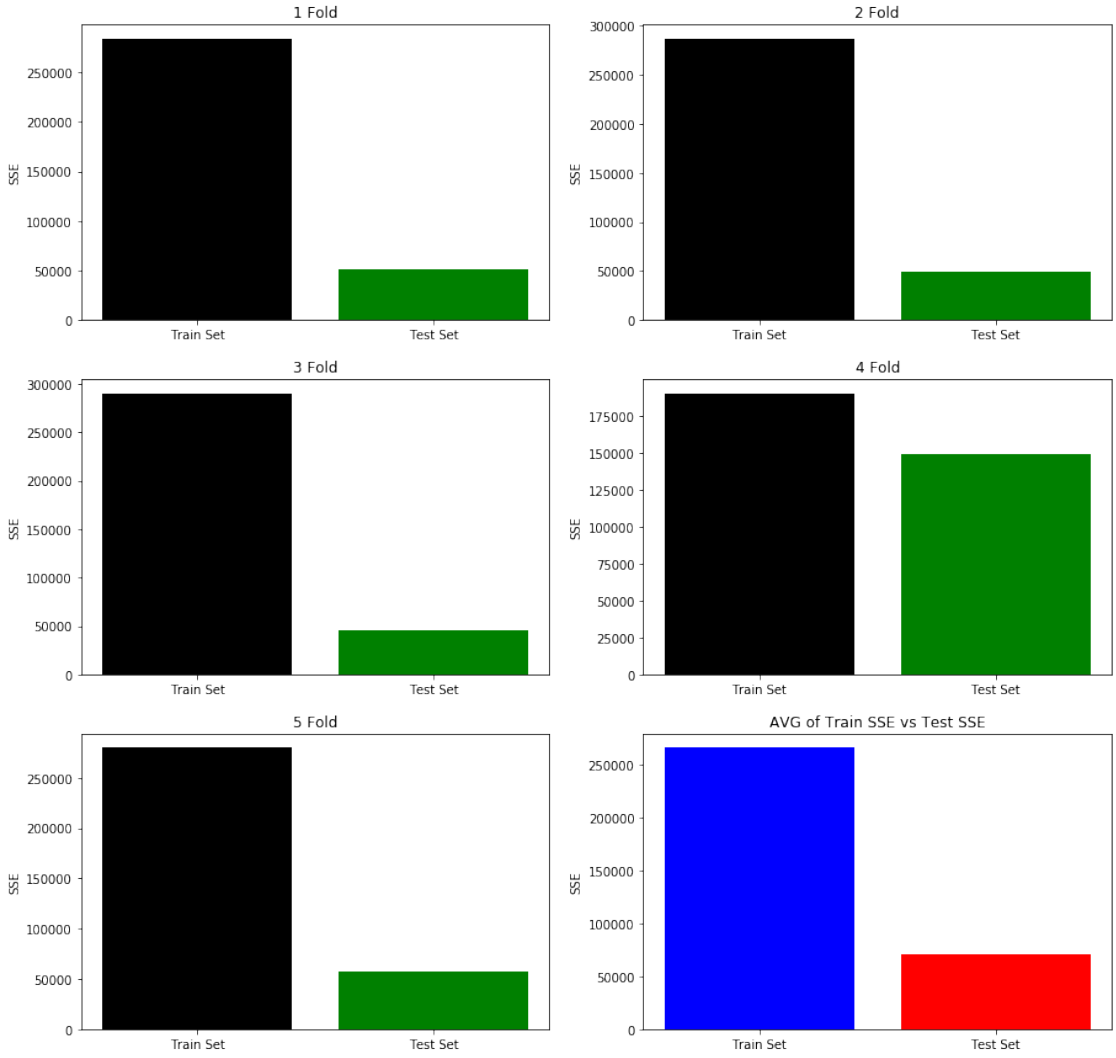


2 With All Variables to Predict Burned Area M1

```
In [6]: from sklearn.model_selection import KFold # import KFold

        X =  X_all
        scaler = MinMaxScaler(feature_range=(0,1))
        X = scaler.fit_transform(X)
        kf = KFold(n_splits=5,shuffle=True) # Define the split - into 2 folds

In [7]: fig, axes = plt.subplots(3, 2,figsize=(15,15))
        plot =[axes[0,0],axes[0,1],axes[1,0],axes[1,1],axes[2,0],axes[2,1]]
        iter_plot = 0
        total_train_SSE = 0
        total_test_SSE = 0
```

```
        total_w = 0
        for train_index, test_index in kf.split(X):
            X_train, X_test = X[train_index], X[test_index]
            Y_train, Y_test = Y[train_index], Y[test_index]
            #Find the weight by using train set
            w_train = np.linalg.lstsq(X_train,Y_train)[0]
            total_w = total_w+w_train

            #Predict the price with train and test set
            pred_train = np.dot(X_train,w_train)
            pred_test = np.dot(X_test,w_train)

            #Calculate SSE for training set and Test set
            train_SSE = sum((pred_train-Y_train)**2)
            test_SSE = sum((pred_test-Y_test)**2)
            total_train_SSE = total_train_SSE + train_SSE
            total_test_SSE = total_test_SSE + test_SSE
            plot[iter_plot].set_title(str(iter_plot+1)+' Fold')
            plot[iter_plot].bar('Train Set',train_SSE, color='k')
            plot[iter_plot].bar('Test Set',test_SSE, color='g')
            plot[iter_plot].set_ylabel('SSE')
            iter_plot = iter_plot+1

        avg_train_SSE = total_train_SSE/k_amount
        avg_test_SSE = total_test_SSE/k_amount
        avg_w = total_w/k_amount
        plot[iter_plot].set_title('AVG of Train SSE vs Test SSE')
        plot[iter_plot].bar('Train Set',avg_train_SSE, color='b')
        plot[iter_plot].bar('Test Set',avg_test_SSE, color='r')
        plot[iter_plot].set_ylabel('SSE')
        print('AVG Train SSE: ',avg_train_SSE,' AVG Test SSE: ',avg_test_SSE)
        print()
        print("Model M1: Area = {:.2f} + {:.2f} * FFMC + {:.2f} * DMC + {:.2f} * DC + {:.2f} *
         + {:.2f} * temp + {:.2f} * RH + {:.2f} * wind +{:.2f} * rain"\
              .format(float(avg_w[0]), float(avg_w[1]), float(avg_w[2]), float(avg_w[3]), \
                      float(avg_w[4]), float(avg_w[5]),float(avg_w[6]),float(avg_w[7]),float(a
```

```
AVG Train SSE:  266232.380103  AVG Test SSE:  70585.8285532

Model M1: Area = 0.00 + 22.11 * FFMC + 17.84 * DMC + -9.19 * DC + -34.00 * ISI + 17.80 * temp +
```



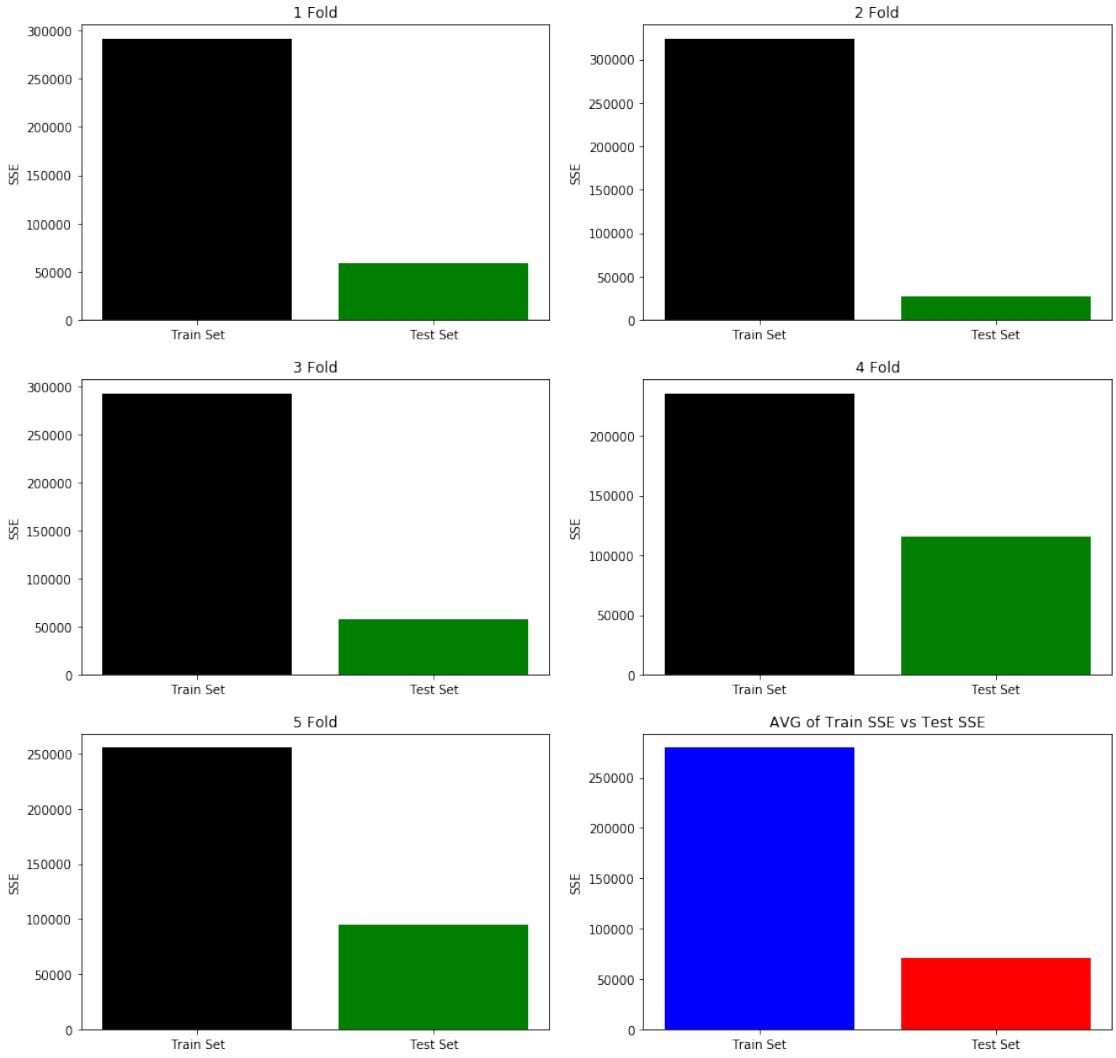
3 With DMC and DC to predict Burned Area M2 (Highest Positive Correlation)

```
In [8]: from sklearn.model_selection import KFold # import KFold

        X =  np.column_stack((ones,X2,X3))# create an array
        scaler = MinMaxScaler(feature_range=(0,1))
        X = scaler.fit_transform(X)
        kf = KFold(n_splits=5,shuffle=True) # Define the split - into 2 folds
```

```
In [9]: fig, axes = plt.subplots(3, 2,figsize=(15,15))
        plot =[axes[0,0],axes[0,1],axes[1,0],axes[1,1],axes[2,0],axes[2,1]]
        iter_plot = 0
        total_train_SSE = 0
```

```
        total_test_SSE = 0
        total_w = 0
        for train_index, test_index in kf.split(X):
            X_train, X_test = X[train_index], X[test_index]
            Y_train, Y_test = Y[train_index], Y[test_index]
            #Find the weight by using train set
            w_train = np.linalg.lstsq(X_train,Y_train)[0]
            total_w = total_w+w_train

            #Predict the price with train and test set
            pred_train = np.dot(X_train,w_train)
            pred_test = np.dot(X_test,w_train)

            #Calculate SSE for training set and Test set
            train_SSE = sum((pred_train-Y_train)**2)
            test_SSE = sum((pred_test-Y_test)**2)
            total_train_SSE = total_train_SSE + train_SSE
            total_test_SSE = total_test_SSE + test_SSE
            plot[iter_plot].set_title(str(iter_plot+1)+' Fold')
            plot[iter_plot].bar('Train Set',train_SSE, color='k')
            plot[iter_plot].bar('Test Set',test_SSE, color='g')
            plot[iter_plot].set_ylabel('SSE')
            iter_plot = iter_plot+1

        avg_train_SSE = total_train_SSE/k_amount
        avg_test_SSE = total_test_SSE/k_amount
        avg_w = total_w/k_amount
        plot[iter_plot].set_title('AVG of Train SSE vs Test SSE')
        plot[iter_plot].bar('Train Set',avg_train_SSE, color='b')
        plot[iter_plot].bar('Test Set',avg_test_SSE, color='r')
        plot[iter_plot].set_ylabel('SSE')
        print('AVG Train SSE: ',avg_train_SSE,' AVG Test SSE: ',avg_test_SSE)
        print()
        print("Model M2: Area = {:.2f} + {:.2f} * DMC + {:.2f} * DC".format(float(avg_w[0]),fl
```

```
AVG Train SSE:  279631.994948  AVG Test SSE:  71152.7367409

Model M2: Area = 0.00 + 21.66 * DMC + 11.16 * DC
```

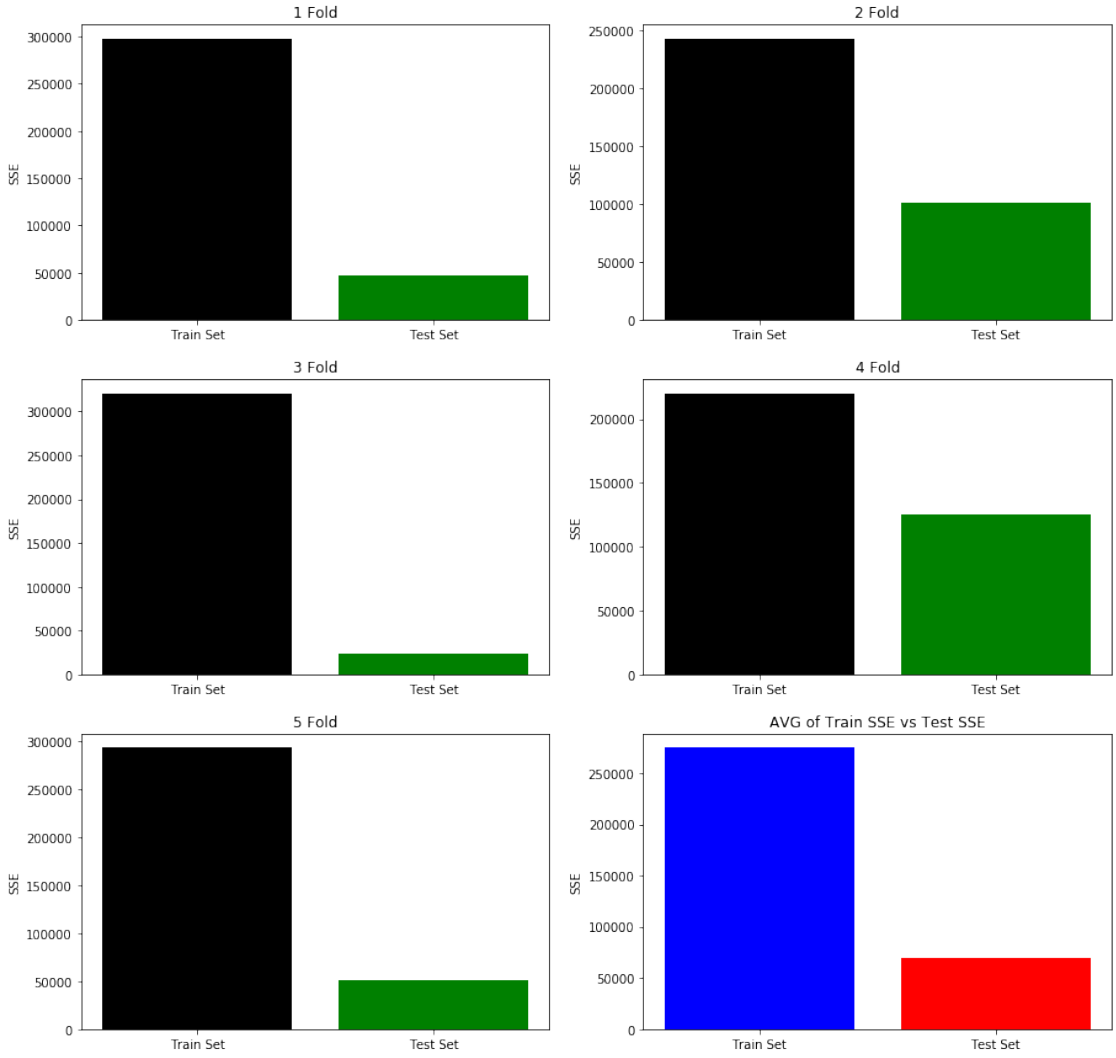


4 With RH and temp to predict Burned Area M3 (Highest Negative Correlation)

```
In [10]: from sklearn.model_selection import KFold # import KFold

         X =  np.column_stack((ones,X5,X6))# create an array
         scaler = MinMaxScaler(feature_range=(0,1))
         X = scaler.fit_transform(X)
         kf = KFold(n_splits=5,shuffle=True) # Define the split - into 2 folds

In [11]: fig, axes = plt.subplots(3, 2,figsize=(15,15))
         plot =[axes[0,0],axes[0,1],axes[1,0],axes[1,1],axes[2,0],axes[2,1]]
         iter_plot = 0
         total_train_SSE = 0
```

```
        total_test_SSE = 0
        total_w = 0
        for train_index, test_index in kf.split(X):
            X_train, X_test = X[train_index], X[test_index]
            Y_train, Y_test = Y[train_index], Y[test_index]
            #Find the weight by using train set
            w_train = np.linalg.lstsq(X_train,Y_train)[0]
            total_w = total_w+w_train

            #Predict the price with train and test set
            pred_train = np.dot(X_train,w_train)
            pred_test = np.dot(X_test,w_train)

            #Calculate SSE for training set and Test set
            train_SSE = sum((pred_train-Y_train)**2)
            test_SSE = sum((pred_test-Y_test)**2)
            total_train_SSE = total_train_SSE + train_SSE
            total_test_SSE = total_test_SSE + test_SSE
            plot[iter_plot].set_title(str(iter_plot+1)+' Fold')
            plot[iter_plot].bar('Train Set',train_SSE, color='k')
            plot[iter_plot].bar('Test Set',test_SSE, color='g')
            plot[iter_plot].set_ylabel('SSE')
            iter_plot = iter_plot+1

        avg_train_SSE = total_train_SSE/k_amount
        avg_test_SSE = total_test_SSE/k_amount
        avg_w = total_w/k_amount
        plot[iter_plot].set_title('AVG of Train SSE vs Test SSE')
        plot[iter_plot].bar('Train Set',avg_train_SSE, color='b')
        plot[iter_plot].bar('Test Set',avg_test_SSE, color='r')
        plot[iter_plot].set_ylabel('SSE')
        print('AVG Train SSE: ',avg_train_SSE,' AVG Test SSE: ',avg_test_SSE)
        print()
        print("Model M3: Area = {:.2f} + {:.2f} * RH + {:.2f} * temp".format(float(avg_w[0]),
```

```
AVG Train SSE:  274840.606274  AVG Test SSE:  69760.2743931

Model M3: Area = 0.00 + 24.77 * RH + 10.48 * temp
```



5 Multipling Correlated Variables to predict Burned Area M4

```
In [12]: df['FFMC * ISI'] = np.array(list(df['FFMC'])) * np.array(list(df['ISI']))
         df['FFMC * temp'] = np.array(list(df['FFMC'])) * np.array(list(df['temp']))
         df['DMC * DC'] = np.array(list(df['DMC'])) * np.array(list(df['DC']))
         df['DMC * temp'] = np.array(list(df['DMC'])) * np.array(list(df['temp']))
         df['DC * temp'] = np.array(list(df['DC'])) * np.array(list(df['temp']))
         df['temp * RH'] = np.array(list(df['temp'])) * np.array(list(df['RH']))

         X = df.iloc[:, [13,14,15,16,17,18]]
         y = df.iloc[:, 12]
         ones = np.ones((268,1))
         X = np.column_stack((ones,X))
```

```
scaler = MinMaxScaler(feature_range=(0,1))
X = scaler.fit_transform(X)
y = list(y)
y = np.array(y)
```

In [13]:
```
scores = []
cv = KFold(n_splits=5, shuffle=True)
k_amount = cv.get_n_splits(X)
lm = LinearRegression()
fig, axes = plt.subplots(3, 2,figsize=(15,15))
plot =[axes[0,0],axes[0,1],axes[1,0],axes[1,1],axes[2,0],axes[2,1]]
iter_plot = 0
total_train_SSE = 0
total_test_SSE = 0
total_w = 0

for train_index, test_index in cv.split(X):
    X_train = X[train_index]
    X_test = X[test_index]
    Y_train = y[train_index]
    Y_test = y[test_index]
    lm.fit(X_train, Y_train)
    w= lm.coef_
    pred_train = np.dot(X_train,w)
    pred_test = np.dot(X_test,w)
    total_w = total_w+w
    #Calculate SSE for training set and Test set
    train_SSE = sum((pred_train-Y_train)**2)
    test_SSE = sum((pred_test-Y_test)**2)
    total_train_SSE = total_train_SSE + train_SSE
    total_test_SSE = total_test_SSE + test_SSE
    plot[iter_plot].set_title(str(iter_plot+1)+' Fold')
    plot[iter_plot].bar('Train Set',train_SSE, color='k')
    plot[iter_plot].bar('Test Set',test_SSE, color='g')
    plot[iter_plot].set_ylabel('SSE')
    iter_plot = iter_plot+1
    scores.append(lm.score(X_test, Y_test))

avg_train_SSE = total_train_SSE/k_amount
avg_test_SSE = total_test_SSE/k_amount
avg_w = total_w/k_amount
plot[iter_plot].set_title('AVG of Train SSE vs Test SSE')
plot[iter_plot].bar('Train Set',avg_train_SSE, color='b')
plot[iter_plot].bar('Test Set',avg_test_SSE, color='r')
plot[iter_plot].set_ylabel('SSE')
print('AVG Train SSE: ',avg_train_SSE,' AVG Test SSE: ',avg_test_SSE)
print()
print("Model M4: Area = {:.2f} + {:.2f} * FFMC*ISI + {:.2f} * FFMC*temp + {:.2f} * DM
```

```
        + {:.2f} * DMC*temp + {:.2f} * DC*temp + {:.2f} * temp*RH "\
              .format(float(avg_w[0]),float(avg_w[1]),float(avg_w[2]),float(avg_w[3]),float(av
                      ,float(avg_w[5]),float(avg_w[6])))
```

```
AVG Train SSE:  326904.855862  AVG Test SSE:  85181.9003617

Model M4: Area = 0.00 + -26.87 * FFMC*ISI + 21.29 * FFMC*temp + -3.43 * DMC*DC+ 27.30 * DMC*ter
```