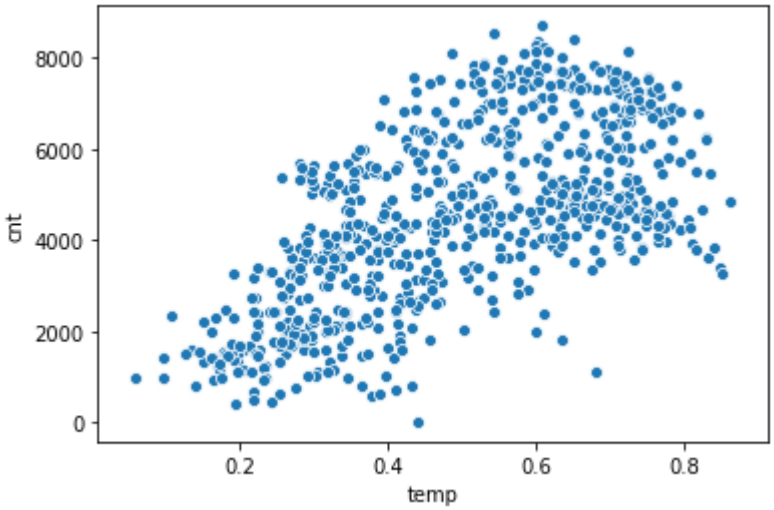
In [1]:

```
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt
from matplotlib import cm
from matplotlib.ticker import LinearLocator, FormatStrFormatter
import numpy as np

import pandas
import seaborn
```

In [2]:

```
df = pandas.read_csv('datasets/bike.csv')
px = df['temp'].values
py = df['cnt'].values
plt.figure()
seaborn.scatterplot(data=df, x='temp',y='cnt')
plt.show()
```



In [3]:

```
def J(px,py,B):
    m,b = B
    return 0.5*np.sum((m*px + b - py)**2)

def VJ(px,py,B):
    m,b = B
    G = np.zeros((2),float)
    G[0] = np.sum( (m*px + b - py)*(px) )
    G[1] = np.sum( (m*px + b - py) )
    return G
```

In [4]:

```
def plot_m_b_3D(px,py,B,vmin=-10000,vmax=10000):
    m,b = B
    error = J(px,py,B)

    N = 100
    rowx = np.linspace(vmin, vmax, N)
    rowy = np.linspace(vmin, vmax, N)
    xx, yy = np.meshgrid(rowx, rowy)
    zz = np.zeros((N, N),float)
    for x in range(N):
        for y in range(N):
             zz[x, y] = J(px,py, [xx[x,y],yy[x,y]] )

    plt.figure(figsize=(15,5))
    plt.subplot(1,3,1)
    plt.title( error )
    seaborn.scatterplot(data=df, x='temp',y='cnt')
    plt.plot( [0,1],[m*0+b,m*1+b],c='red' )

    ax = plt.subplot(1,3,2,projection='3d')
    surf = ax.plot_surface(xx, yy, zz, cmap=cm.coolwarm, linewidth=0, antialiased=Fa
lse)
    ax.scatter(m,b,error,c='r')
    ax.scatter(m,b,0,c='r')
    ax.set_xlabel('m')
    ax.set_ylabel('b')

    ax = plt.subplot(1,3,3,projection='3d')
    ax.contour(xx,yy,zz,zdir='z',offset=-1000,cmap=cm.coolwarm)
    ax.scatter(m,b,0,c='r')
    ax.set_xlabel('m')
    ax.set_ylabel('b')

    plt.show()
```

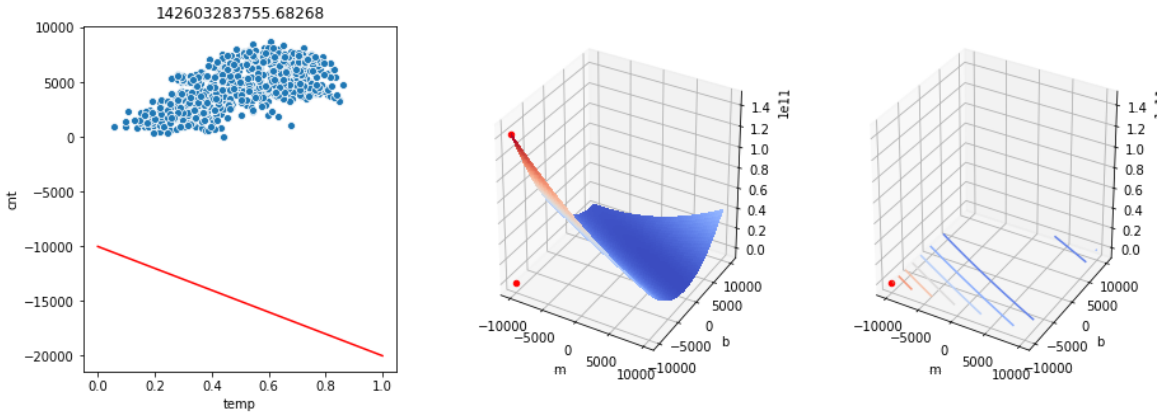
In [5]:

```
def GradientDescent(px,py,B):
    MaxIter = 500000
    Eps = 1e-5
    G = VJ(px,py,B)
    nG = np.linalg.norm(G)
    k = 0
    print('k:',k,'m:',B[0],'b',B[1],'error:',J(px,py,B),'||VJ||:',nG)
    plot_m_b_3D(px,py,B)
    while nG>Eps and k<MaxIter:
        P = -G/nG
        alpha = 0.1
        B = B + alpha*P
        G = VJ(px,py,B)
        nG = np.linalg.norm(G)
        k=k+1
        if k%10000==0:
            print('k:',k,'m:',B[0],'b',B[1],'error:',J(px,py,B),'||VJ||:',nG)
        if k%50000==0:
            plot_m_b_3D(px,py,B)
    return B
```

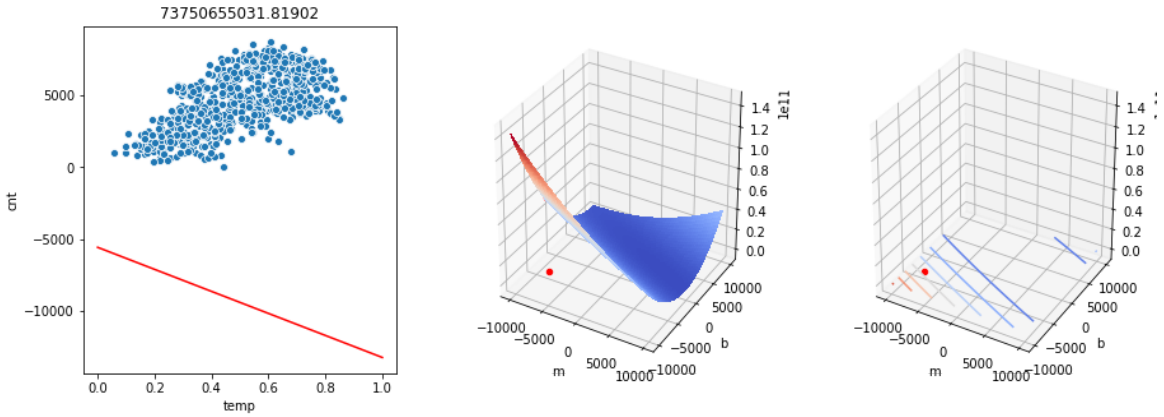
In [6]:

```
m, b = -10000, -10000
B = [m,b]
GradientDescent(px,py,B)
```

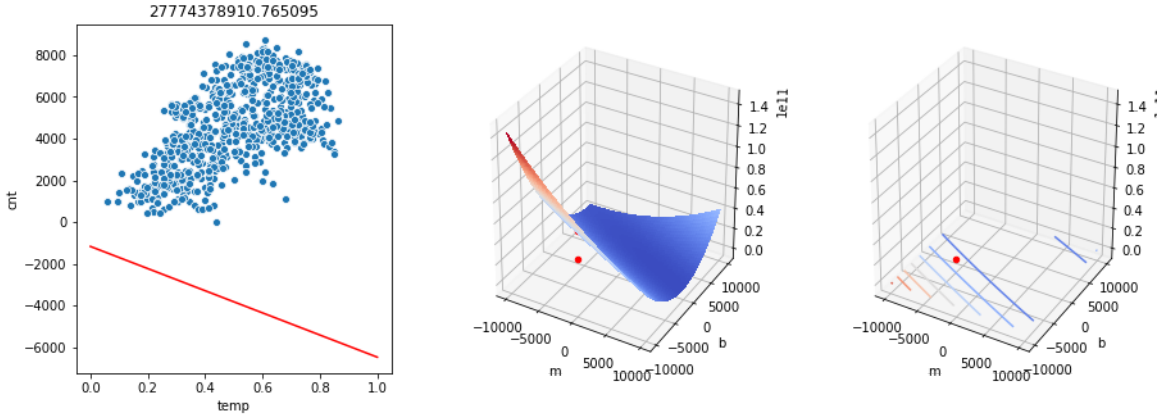
```
k: 0 m: -10000 b -10000 error: 142603283755.68268 ||VJ||: 16058430.39418
1622
```



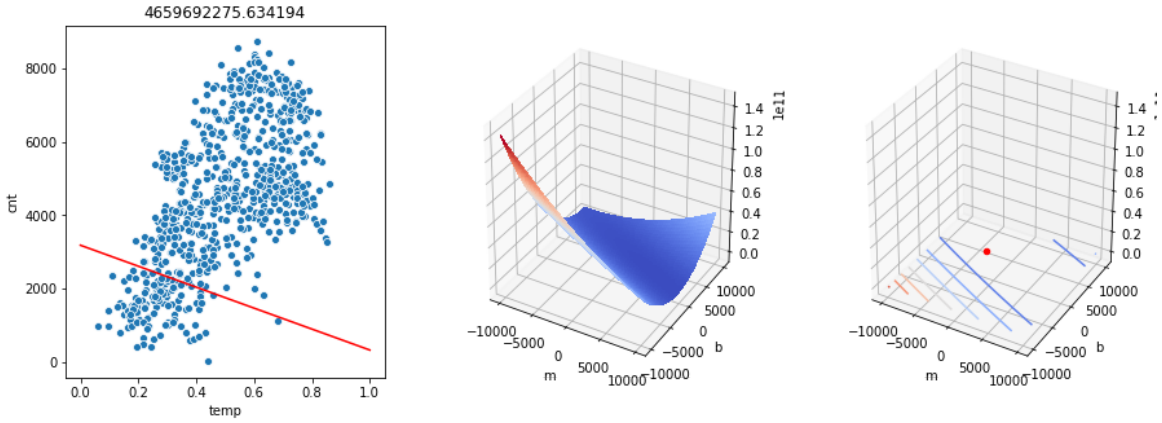

```
k: 10000 m: -9535.555390619575 b -9114.39785234546 error: 127002446739.3
027 ||VJ||: 15143246.189507406
k: 20000 m: -9070.452171847004 b -8229.141423991416 error: 112316785799.
0115 ||VJ||: 14228078.741702145
k: 30000 m: -8604.60402679003 b -7344.276779694007 error: 98546282547.34
964 ||VJ||: 13312931.452120166
k: 40000 m: -8137.906396390539 b -6459.859890562743 error: 85690914726.0
7788 ||VJ||: 12397808.71394712
k: 50000 m: -7670.230935133285 b -5575.959701038368 error: 73750655031.8
1902 ||VJ||: 11482716.303261068
```



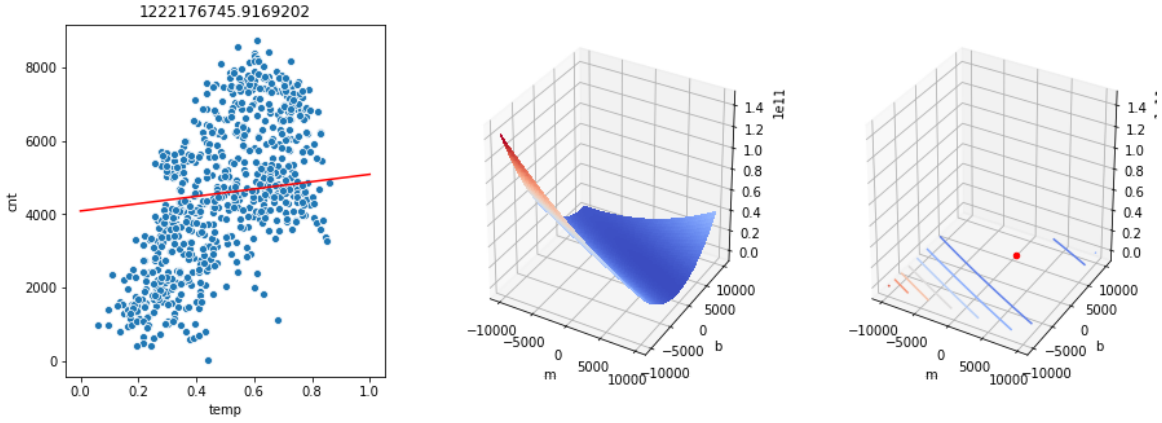

```
k: 60000 m: -7201.417683103158 b -4692.662484335984 error: 62725469458.1
41556 ||VJ||: 10567661.971361097
k: 70000 m: -6731.263722543909 b -3810.0781963145696 error: 52615314892.
96787 ||VJ||: 9652656.3707465
k: 80000 m: -6259.506234183535 b -2928.3500407809597 error: 43420135529.
08629 ||VJ||: 8737714.557096267
k: 90000 m: -5785.796265860108 b -2047.6694159048516 error: 35139857304.
58725 ||VJ||: 7822858.534325536
k: 100000 m: -5309.6563391635445 b -1168.300340849935 error: 2777437891
0.765095 ||VJ||: 6908121.799939346
```



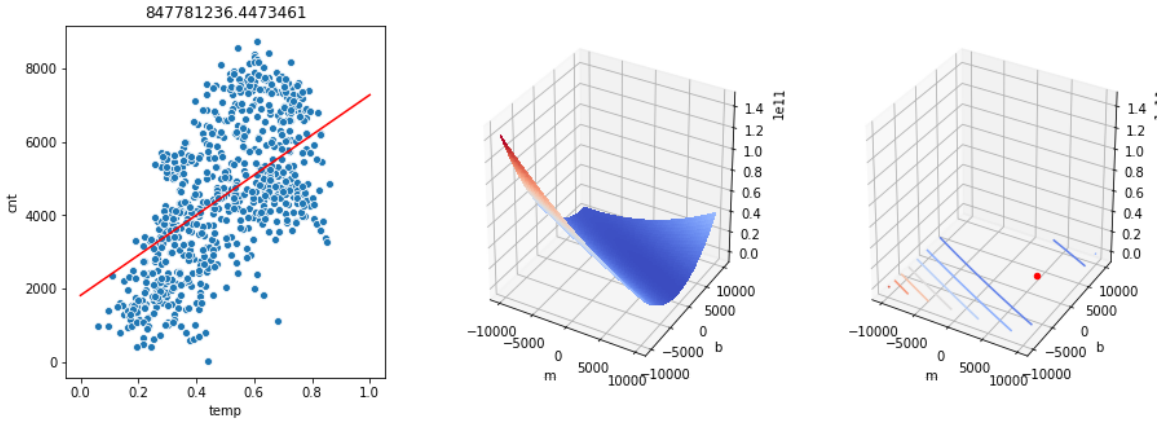

```
k: 110000 m: -4830.408236417218 b -290.6216399964325 error: 21323556454.
98288 ||VJ||: 5993558.004623439
k: 120000 m: -4347.041604857323 b 584.7949547139268 error: 15787175495.3
25058 ||VJ||: 5079258.850534466
k: 130000 m: -3857.9535539060344 b 1457.0264512264037 error: 1116489542
9.515266 ||VJ||: 4165395.2349139
k: 140000 m: -3360.369380417699 b 2324.4350794394845 error: 7456125073.6
53188 ||VJ||: 3252326.643611978
k: 150000 m: -2848.8205151331217 b 3183.667131445314 error: 4659692275.6
34194 ||VJ||: 2340961.394950759
```



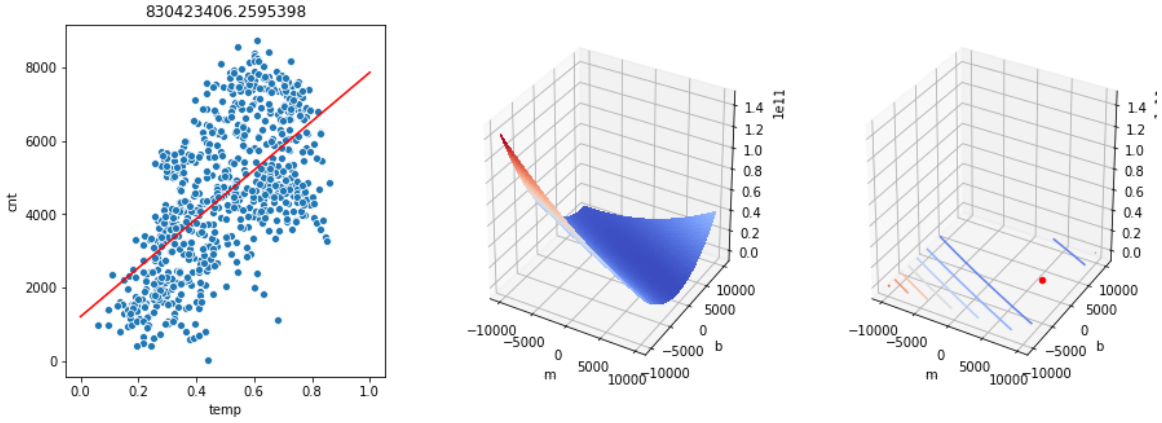

```
k: 160000 m: -2309.9271347112917 b 4025.9295525170355 error: 2772684792.
2854853 ||VJ||: 1434449.734208182
k: 170000 m: -1692.5201167141279 b 4810.707685979316 error: 1783208875.0
458107 ||VJ||: 555441.9959627612
k: 180000 m: -790.8012168722777 b 4984.238387483661 error: 1508709848.32
78294 ||VJ||: 163124.87380446334
k: 190000 m: 105.45076435691617 b 4540.970135442068 error: 1355660747.83
58934 ||VJ||: 143251.4874468894
k: 200000 m: 996.6644838389701 b 4087.386511016736 error: 1222176745.916
9202 ||VJ||: 123716.51842433655
```



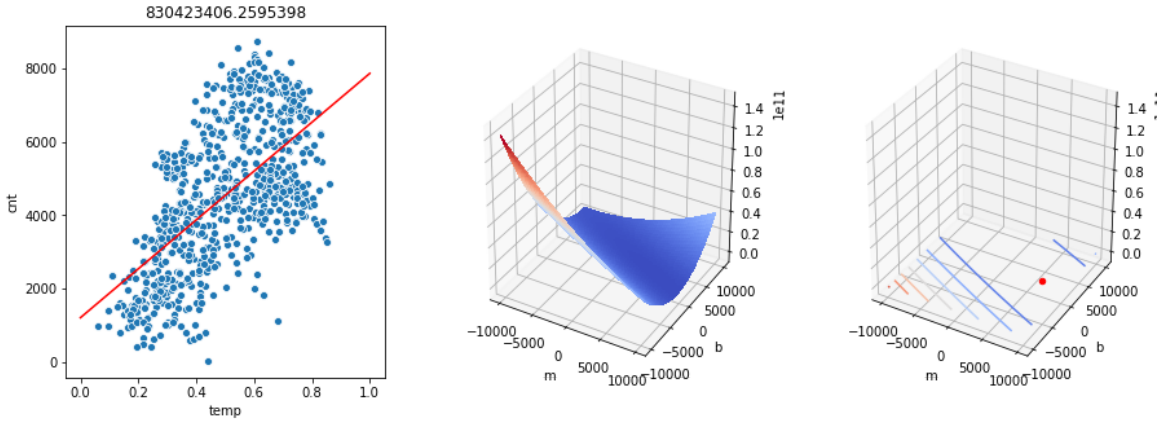

```
k: 210000 m: 1887.8651376019945 b 3633.77721356756 error: 1108227710.798
6689 ||VJ||: 104181.55181217137
k: 220000 m: 2779.0657777998367 b 3180.1678894654915 error: 1013813642.2
925203 ||VJ||: 84646.58519999553
k: 230000 m: 3670.266417994093 b 2726.558565354507 error: 938934540.3985
059 ||VJ||: 65111.6185878031
k: 240000 m: 4561.467058185975 b 2272.949241244731 error: 883590405.1168
352 ||VJ||: 45576.65197566265
k: 250000 m: 5452.667698375683 b 1819.339917136021 error: 847781236.4473
461 ||VJ||: 26041.68536356957
```



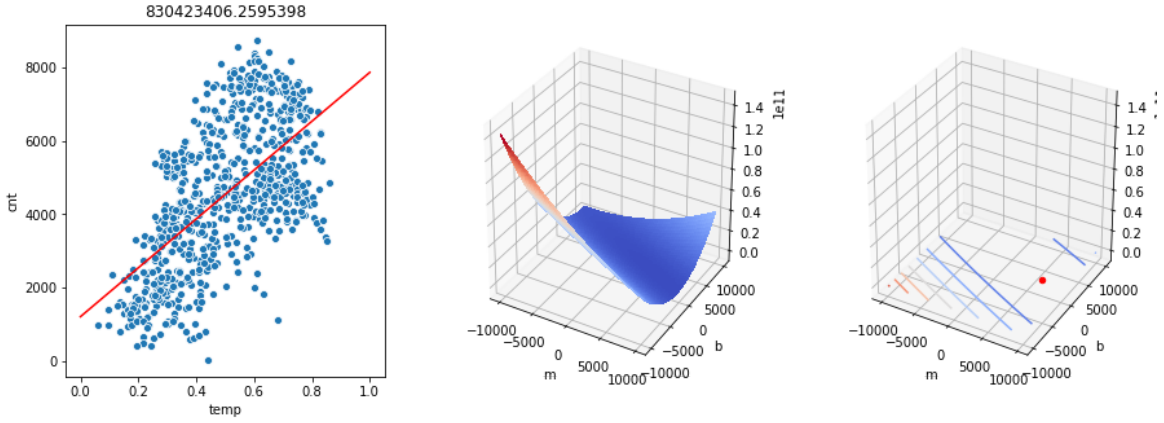

```
k: 260000 m: 6343.868338565392 b 1365.730593027382 error: 831507034.3898
809 ||VJ||: 6506.71875147709
k: 270000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 280000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 290000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 300000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
```



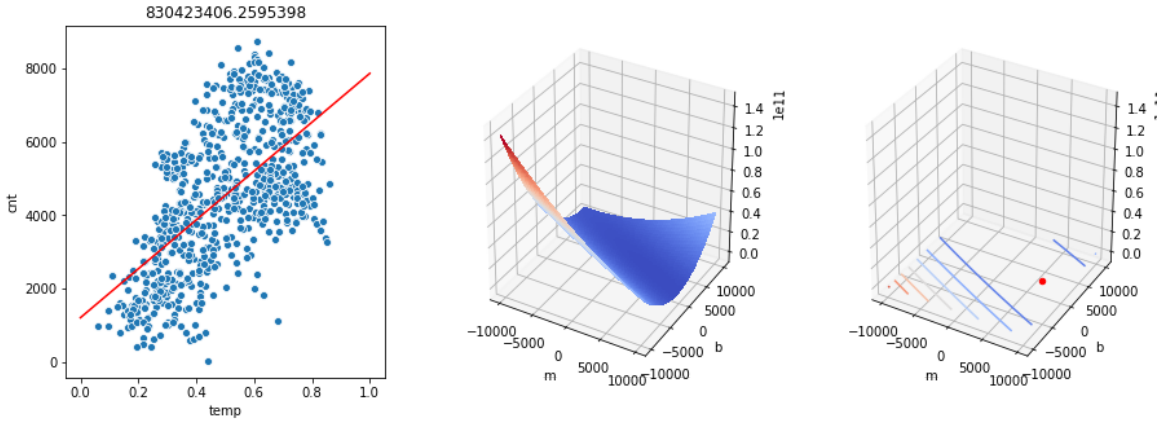

```
k: 310000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 320000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 330000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 340000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 350000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
```



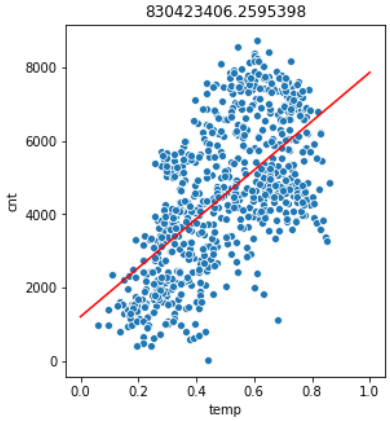

```
k: 360000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 370000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 380000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 390000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 400000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
```

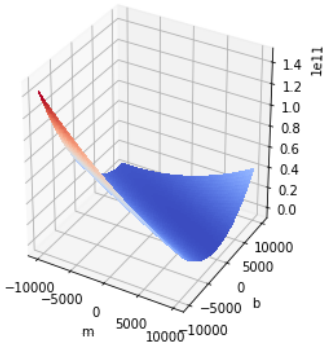


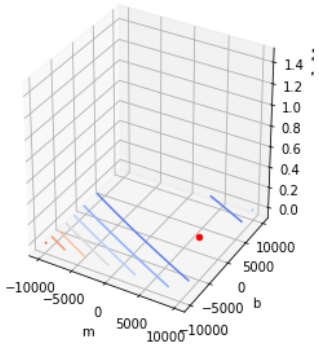

```
k: 410000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 420000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 430000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 440000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 450000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
```




```
k: 460000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 470000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 480000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 490000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
k: 500000 m: 6640.674384873361 b 1214.5721492811679 error: 830423406.259
5398 ||VJ||: 71.86320434418246
```







Out[6]:

```
array([6640.67438487, 1214.57214928])
```