COVID19_2604

April 26, 2020

1 Dados COVID19 em .ipynb 26/04/2020

Tentando importar e utilizar os dados do Ministério da Saúde em https://covid.saude.org.br
A url muda diariamente, há uma série de caracteres em primeira vista aleatórios que é atual
O site não disponibiliza dados de SRAG, apenas uma tabela repetida do COVID desatualizada.
Nova tabela com dados do Brasil (população)
Dados de SRAG da fiocruz em padrão brasileiro (109,0009) como transformar o arquivo em pad

1.1 Gráficos dos Dados

Mostrar infectados e mortes confirmados diariamente
Mostrar infectados e mortes confirmados acumulados
Mostrar dados separados por região e por estado

Mostrar dados de SRAG e comparar com o aumento dos números confirmados de COVID
Dados em semana epidemiológica

1.2 Estimativas (Regressão)

Estimar próximos números (até 7 dias?) utilizando 2, 3 ou 4 (todos?) dias anteriores e regr
Estimar curvas com ajuda dos dados de SRAG inconclusivos (qual a porcentagem de testes inco

1.3 Modelo de Contágio

Utilizar dados adquiridos para rodar um modelo epidemiológico que utiliza valores de reprod

[1]:
```
import pandas as pd
import numpy as np
from datetime import datetime,timedelta
from sklearn.metrics import mean_squared_error
from scipy.stats import norm
from scipy.optimize import curve_fit
from scipy.optimize import fsolve
import matplotlib.pyplot as plt
%matplotlib inline

url_B = "https://raw.githubusercontent.com/Yannngn/COVID19-04-20/master/brasil.
 ↪csv"
```

```
url_C = "https://mobileapps.saude.gov.br/esus-vepi/files/
 ↪unAFkcaNDeXajurGB7LChj8SgQYS2ptm/
 ↪3d784af876ac289233fb9a2d189f71c4_Download_COVID19_20200426.csv"
```

[2]:
```
brasil = pd.read_csv(url_B, sep = ';')
df = pd.read_csv(url_C, sep = ";")
```

[3]:
```
FMT = '%Y-%m-%d'

date = df['data']
regi = df['regiao']

df['data'] = date.map(lambda x : (datetime.strptime(x, FMT) - datetime.
 ↪strptime("2020-01-30", FMT)).days)
```

[4]:
```
df1 = df.loc[:, ['data', 'casosAcumulados', 'casosNovos', 'obitosAcumulados',␣
 ↪'obitosNovos']]
dfs = df.loc[:, ['regiao', 'data', 'casosAcumulados', 'casosNovos',␣
 ↪'obitosAcumulados', 'obitosNovos', 'estado']]
df_UF = df.loc[:, ['estado', 'data', 'casosAcumulados', 'casosNovos',␣
 ↪'obitosAcumulados', 'obitosNovos']]
```

[5]:
```
df1 = df1.groupby("data").sum()

# total of days since 2020-01-30 - x
x = list(df1.index)
```

[65]:
```
def exponential_model (x, a, b, c) :
    return a * np.exp (b * (x - c))

#curve_fit(f, xdata, ydata, p0=None, sigma=None, absolute_sigma=False,␣
 ↪check_finite=True, bounds=(-inf, inf), method=None, jac=None,␣
 ↪**kwargs)[source]

def exp_param (R, X) :
    a = np.exp(X[2] * (((np.log(R[2]))/X[2]) - ((np.log(R[1]) - np.log(R[0]))/
 ↪(X[1] - X[0]))))
    b = (np.log(R[2])/X[2]) - (1/X[2])*(((np.log(R[0])/X[0]) - (np.log(R[1])/
 ↪X[1]))/((X[0])**(-1) - (X[1])**(-1)))
    return [a, b]

def exp_est (R, X) :
    np.random.seed(max(x))
    a = np.exp(X[2] * (((np.log(R[2]))/X[2]) - ((np.log(R[1]) - np.log(R[0]))/
 ↪(X[1] - X[0]))))
```

```
    b = (np.log(R[2])/X[2]) - (1/X[2])*(((np.log(R[0])/X[0]) - (np.log(R[1])/
↪X[1]))/((X[0])**(-1) - (X[1])**(-1)))
    return a * np.exp(b * (max(x) + 1)) + norm.rvs(size = 1,scale = 0.05 *␣
↪(max(x) + 1))
```

[80]:
```
desc = ["total cases", "new cases", "total deaths", "new deaths"]
print("The errors of the exponential model parameters of: \n")

for i in range(4) :
    y = list(df1.iloc[:, i])
    exp_p = exp_param([y[-4], y[-3], y[-1]], [x[-4], x[-3], x[-1]])
    exponential_fit = curve_fit(exponential_model, x, y, p0 = [exp_p[0] - 1,␣
↪exp_p[1], 1])
    exponential_sol = int(fsolve(lambda x : exponential_model(x,␣
↪exponential_fit[0][0], exponential_fit[0][1],
                                                              exponential_fit[0][2])␣
↪- int(exponential_fit[0][2]), exponential_fit[0][1]))

    exponential_errors = [np.sqrt(exponential_fit[1][j][j]) for j in [0, 1, 2]]

    print(desc[i] + " numbers are: " + str(exponential_errors) + "\n")
```

```
The errors of the exponential model parameters of:

total cases numbers are: [29549527.23339656, 0.0014713490334887886,
3683324.2353184004]

new cases numbers are: [29647029.878081262, 0.00564550143185401,
24637906.245934166]

total deaths numbers are: [46760.91051310341, 0.0017899558510270828,
685419.6248960244]

new deaths numbers are: [104741244.26413523, 1010.0014078680232,
466721014.45925546]
```

1.4 logistic model

a refers to the infection speed b is the day with the maximum infections occurred c is the total number of recorded infected people at the infection's end

velocidade da infecção: 2

dia de máximo de infecções: daqui a 2 semanas dia de máximo de mortes: daqui a 4 semanas

população do Brasil: 209.500.000 população máxima infectada: 60% população máxima infectada num dia: 2% população máxima morta: 0.6% população máxima morta num dia: 0.02%

[72]:
```
# logistic model of the evolution of the contamination in Brazil

def logistic_model (x, a, b, c) :
    return c / (1 + np.exp ( - (x - b) / a))

# curve_fit(f, xdata, ydata, p0=None, sigma=None, absolute_sigma=False,␣
 ↪check_finite=True, bounds=(-inf, inf), method=None, jac=None,␣
 ↪**kwargs)[source]

a0 = 1.7

b0 = df1.index.size + 31
b1 = b0 + 14

pBrasil = brasil.at[brasil['UF'].eq('BR').idxmax(),'População']
c0 = 0.4 * pBrasil
c1 = 0.02 * pBrasil
c2 = 0.02 * c0
c3 = 0.02 * c2

list(df1)[0]
```

[72]:
```
'casosAcumulados'
```

[68]:
```
print("The errors of the logistic model parameters of: \n")

for i in range(4) :
    y = list(df1.iloc[:, i])

    logistic_fit = curve_fit(logistic_model, x, y, p0 = [a0, b0, c0])
    logistic_sol = int(fsolve(lambda x : logistic_model(x, logistic_fit[0][0],␣
 ↪logistic_fit[0][1],
                                                        logistic_fit[0][2]) -␣
 ↪int(logistic_fit[0][2]), logistic_fit[0][1]))

    logistic_errors = [np.sqrt(logistic_fit[1][j][j]) for j in [0, 1, 2]]

    print(desc[i] + " numbers are: " + str(logistic_errors) + "\n")
```

```
The errors of the logistic model parameters of:

total cases numbers are: [0.19643117596899176, 0.7838791957251554,
4875.948572186694]

new cases numbers are: [1.8745847596010865, 9.71577324953647,
4036.8670569308015]
```

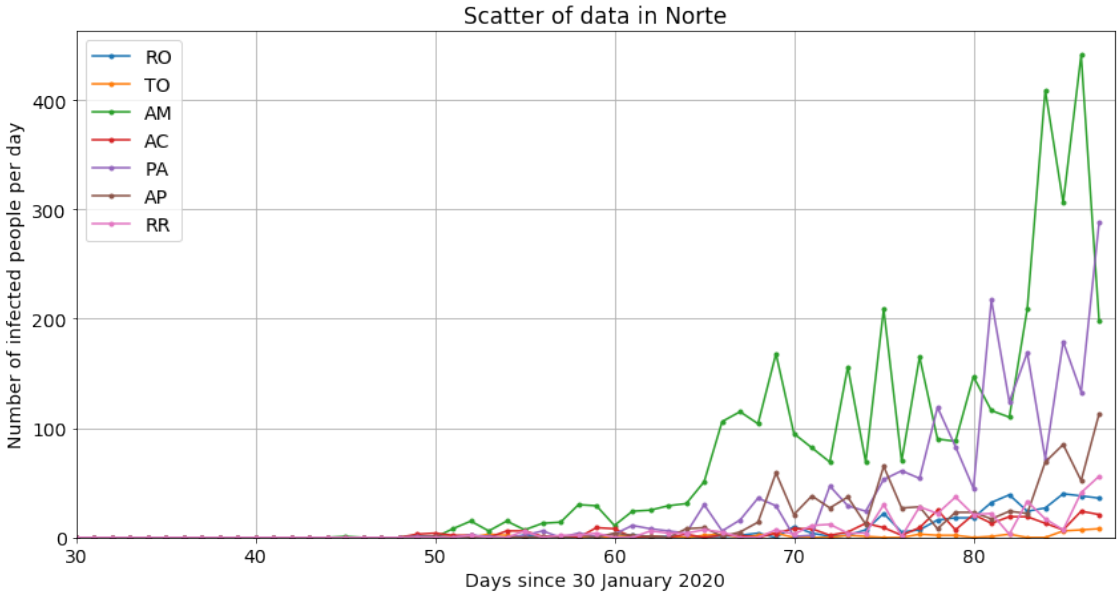
```
total deaths numbers are: [0.20478796817648426, 0.7850528821072706,
378.8170501871789]

new deaths numbers are: [1.7505456735312865, 5.529884177819141,
126.4653695570321]
```

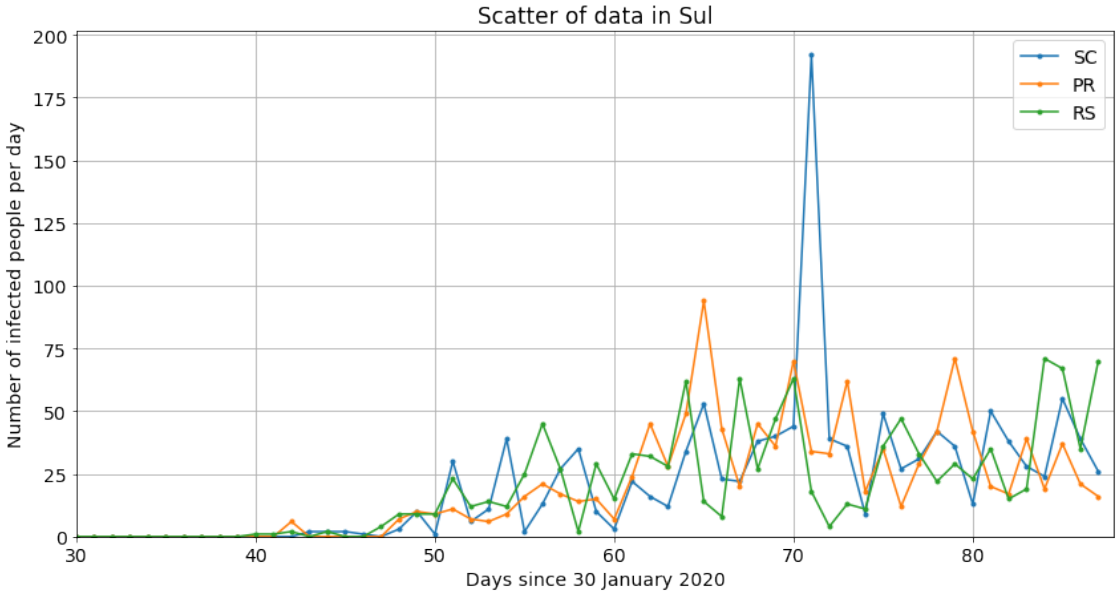
2 Gráficos

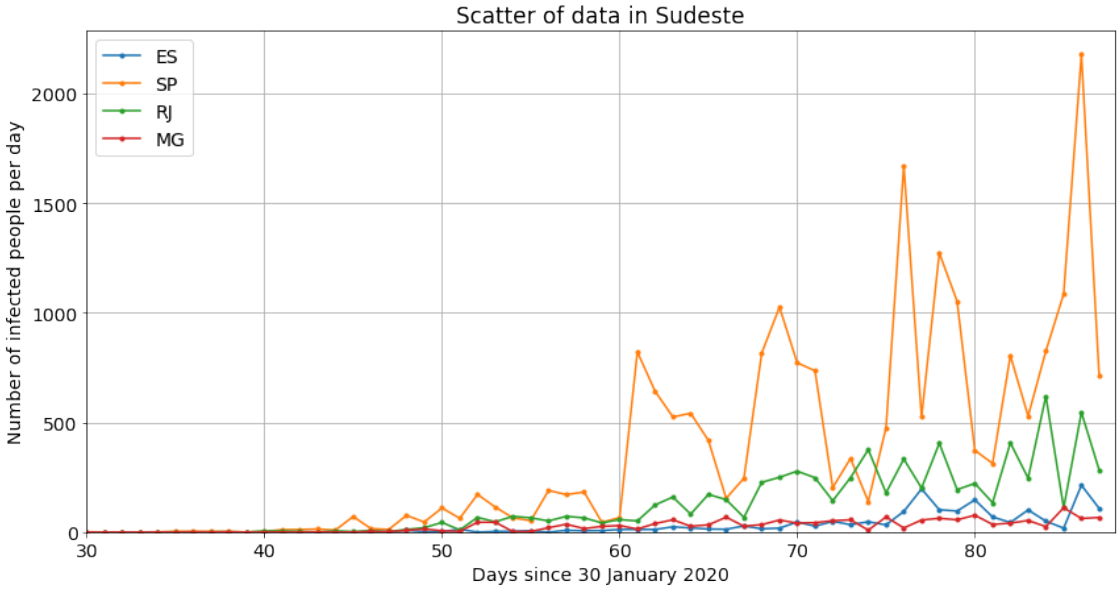
2.1 Cores

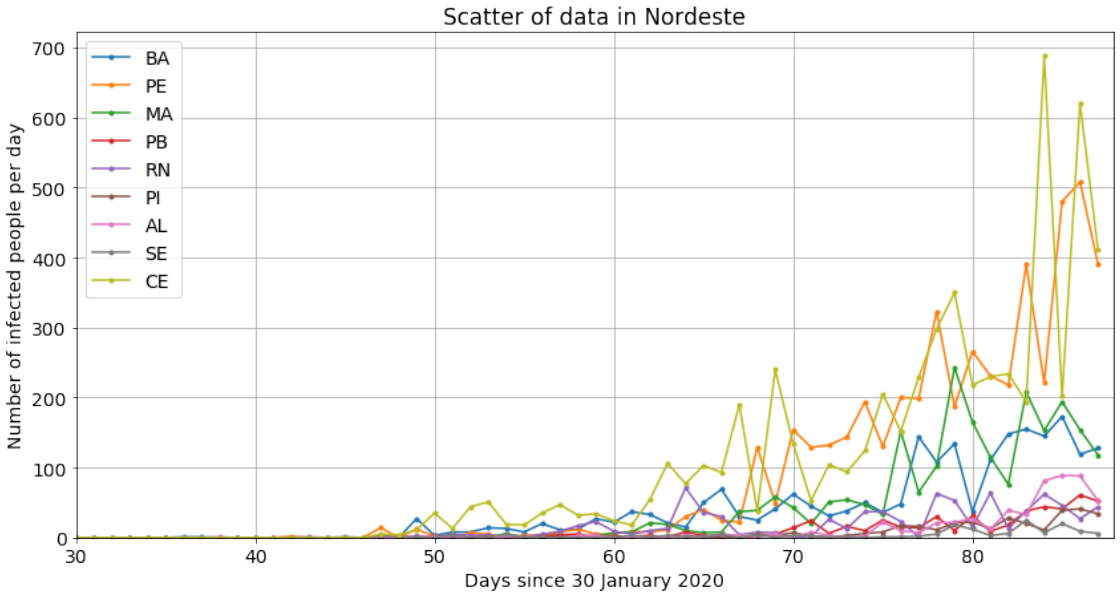
```
branco --> #c2cdd8
cinza --> #a1a9b4
azul --> #3881b8
azul --> #235174
preto --> #1d2b49
```

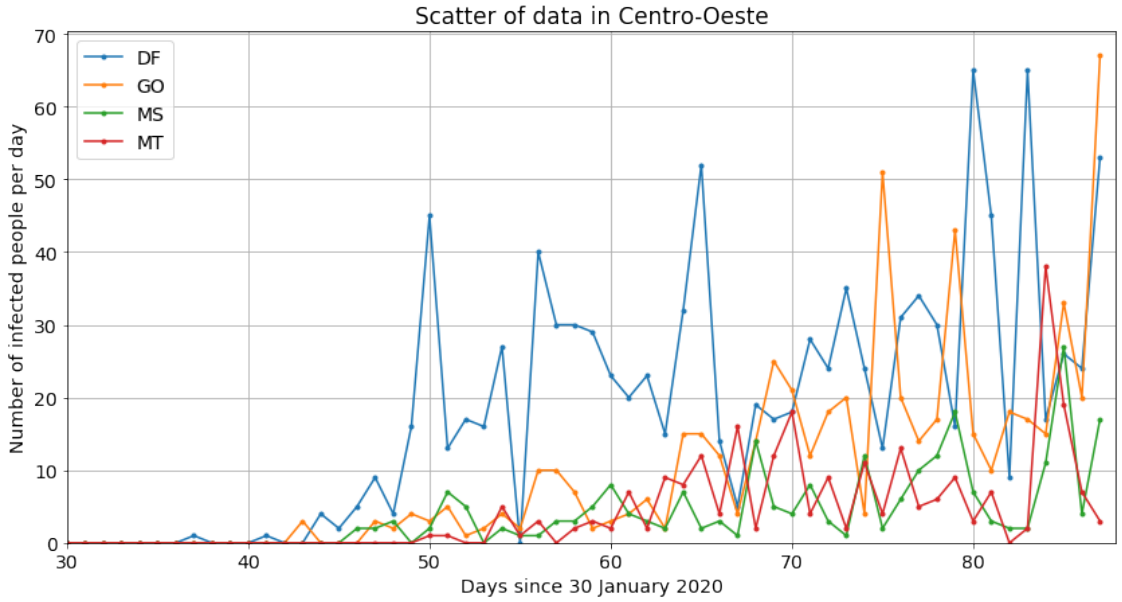
[69]:
```
plt.rc('font', size=14)
plt.rcParams['figure.figsize'] = [14, 7]

dfs = dfs.sort_values("data")
y = list(dfs.iloc[:, 3])

# Real data
# Brazilian areas separated

regioes = dfs["regiao"].unique()
estados = list(dfs["estado"].unique())

for r in regioes :
    plt.grid(True)
    for e in estados :
        yx = max(dfs[dfs['regiao'] == r].iloc[:, 3])
        uf = brasil.at[brasil['UF'].eq(e).idxmax(), "Regiao"]
        if uf == r :
            xs = list(dfs[dfs['estado'] == e].iloc[:, 1])
            ys = list(dfs[dfs['estado'] == e].iloc[:, 3])
            plt.plot(xs, ys, marker = '.', label = e)
    plt.title("Scatter of data in " + r)
    plt.legend()
    plt.xlabel("Days since 30 January 2020")
    plt.ylabel("Number of infected people per day")
    plt.xlim(30, max(xs) * 1.01)
    plt.ylim(0, yx * 1.05)
    plt.show()
```


Scatter of data in Norte
RO
TO
AM
AC
PA
AP
RR
Number of infected people per day
Days since 30 January 2020
0
100
200
300
400
30
40
50
60
70
80


Scatter of data in Sul
SC
PR
RS
Number of infected people per day
Days since 30 January 2020
0
25
50
75
100
125
150
175
200
30
40
50
60
70
80


Scatter of data in Sudeste
ES
SP
RJ
MG
Number of infected people per day
Days since 30 January 2020
0
500
1000
1500
2000
30
40
50
60
70
80

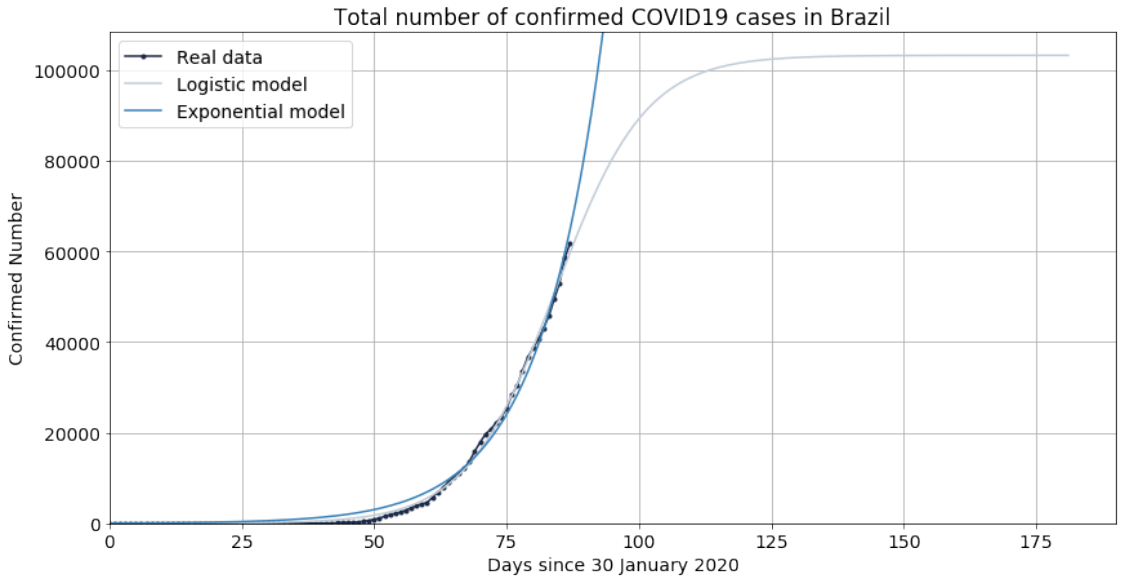

Scatter of data in Nordeste
BA
PE
MA
PB
RN
PI
AL
SE
CE
Number of infected people per day
Days since 30 January 2020
0
100
200
300
400
500
600
700
30
40
50
60
70
80



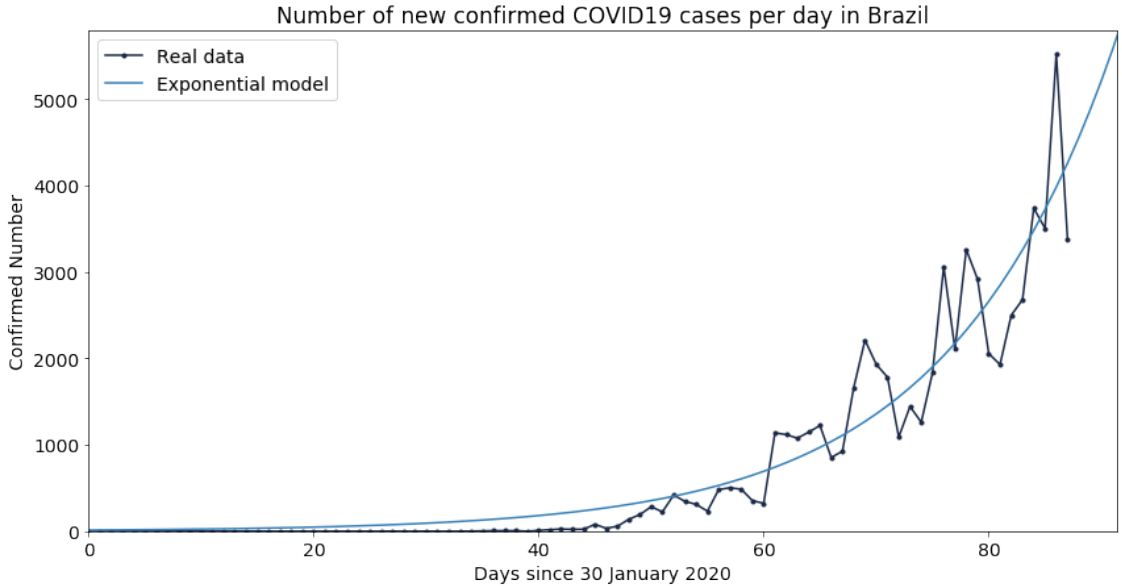
[77]:
```
ttl = ["Total number of confirmed COVID19 cases in Brazil",
       "Number of new confirmed COVID19 cases per day in Brazil",
       "Total number of deceased in Brazil",
       "Number of new confirmed deceased per day in Brazil"]

for f in range(4) :

    plt.grid(True)
    plt.rc('font', size=14)
    plt.rcParams['figure.figsize'] = [14, 7]

    y = list(df1.iloc[:, f])

    logistic_fit = curve_fit(logistic_model, x, y, p0 = [a0, b0, c0])
    logistic_sol = int(fsolve(lambda x : logistic_model(x, logistic_fit[0][0],␣
↪logistic_fit[0][1],
                                                        logistic_fit[0][2]) -␣
↪int(logistic_fit[0][2]),
                                logistic_fit[0][1]))

    exp_p = exp_param([y[-6], y[-3], y[-1]], [x[-6], x[-3], x[-1]])
    exponential_fit = curve_fit(exponential_model, x, y, p0 = [exp_p[0] - 1,␣
↪exp_p[1], 1])
    exponential_sol = int(fsolve(lambda x : exponential_model(x,␣
↪exponential_fit[0][0], exponential_fit[0][1],
                                                              ␣
↪exponential_fit[0][2]) - int(exponential_fit[0][2]),
```

```
                                exponential_fit[0][1]))

    pred_x = list(range(max(x), logistic_sol))

    # Real data
    plt.plot(x, y, marker = '.', label = "Real data", color = "#1d2b49")

    # Predicted logistic curve for the total data
    if (f == 0 or f == 2) :

        plt.plot(x + pred_x, [logistic_model(i, logistic_fit[0][0],␣
↪logistic_fit[0][1], logistic_fit[0][2])
                              for i in x + pred_x], label = "Logistic model",␣
↪color = "#c2cdd8")
        print("Expected final values: end of spread in " + str(max(pred_x) -␣
↪max(x))
              + " days, with " + str(round(logistic_fit[0][2], 3)) + "␣
↪confirmed numbers in Brazil")

    # Predicted exponential curve
    plt.plot(x + pred_x, [exponential_model(i, exponential_fit[0][0],␣
↪exponential_fit[0][1], exponential_fit[0][2])
                          for i in x + pred_x], label = "Exponential model",␣
↪color = "#3881b8")

    plt.title(ttl[f])
    plt.legend()
    plt.xlabel("Days since 30 January 2020")
    plt.ylabel("Confirmed Number")

    if (f == 0 or f == 2) :
        plt.xlim(0, max(pred_x) * 1.05)
        plt.ylim(0, logistic_fit[0][2] * 1.05)
    else :
        plt.ylim(0, max(y) * 1.05)
        plt.xlim(0, max(x) * 1.05)
    plt.show()
    print("Next estimated total number of confirmed cases is " +
          str(round(exponential_model(max(x) + 1, exponential_fit[0][0],␣
↪exponential_fit[0][1], exponential_fit[0][2]), 3)))
```

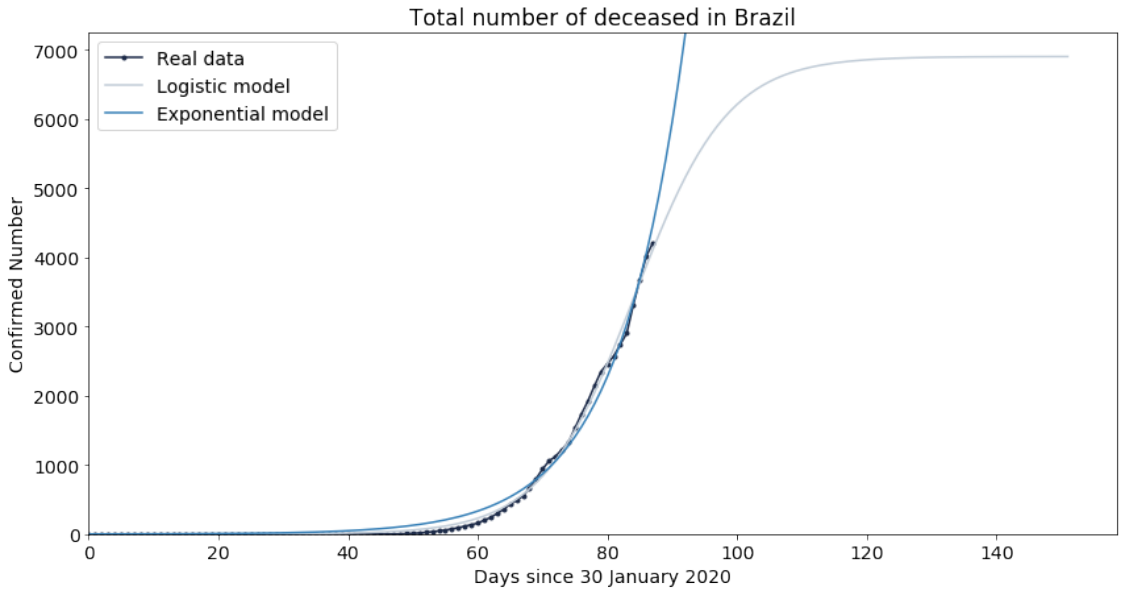
```
Expected final values: end of spread in 94 days, with 103227.906 confirmed
numbers in Brazil
```



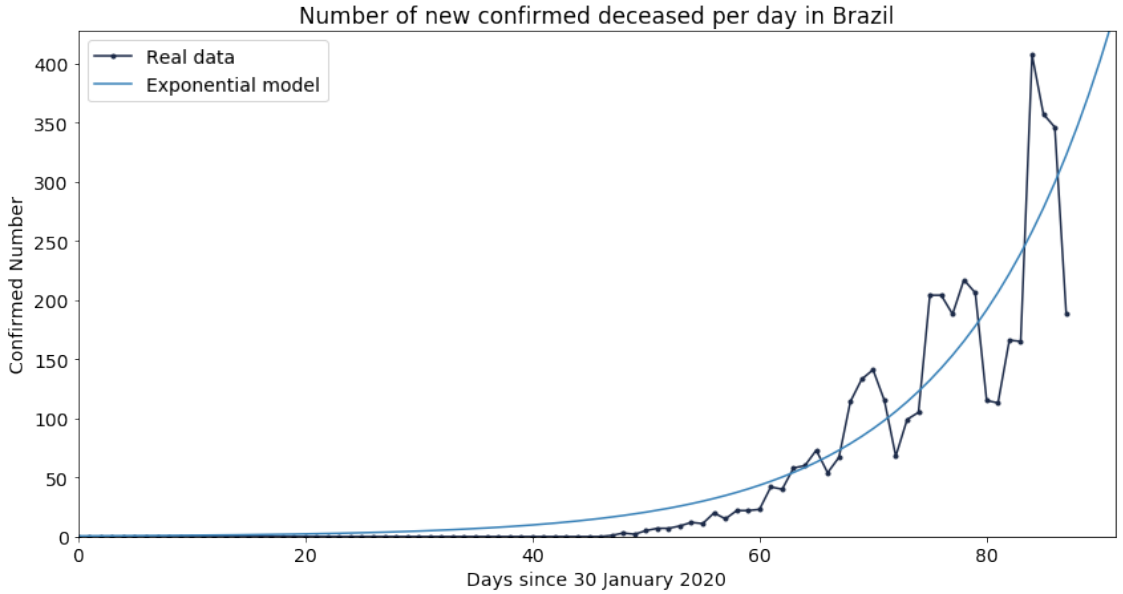

```
Next estimated total number of confirmed cases is 70496.064

C:\Users\calad\anaconda3\lib\site-packages\ipykernel_launcher.py:2:
RuntimeWarning: overflow encountered in exp

C:\Users\calad\anaconda3\lib\site-packages\scipy\optimize\minpack.py:162:
RuntimeWarning: The iteration is not making good progress, as measured by the
  improvement from the last ten iterations.
  warnings.warn(msg, RuntimeWarning)
```



```
Next estimated total number of confirmed cases is 4552.568
Expected final values: end of spread in 64 days, with 6901.513 confirmed numbers
in Brazil
```




```
Next estimated total number of confirmed cases is 4915.932
```




```
Next estimated total number of confirmed cases is 347.1
```

[25]:
```
plt.grid(True)
plt.rc('font', size=14)
plt.rcParams['figure.figsize'] = [14, 7]

# Real data

y = list(df1.iloc[:, 0])
plt.plot(x, y, marker = '.', label = "Real case number", color = "#3881b8")

y = list(df1.iloc[:, 2])

plt.plot(x, y, marker = '.', label = "Real deceased number", color = "#1d2b49")

y = list(df1.iloc[:, 2].multiply(100))

plt.plot(x, y, marker = '.', label = "estimated case number", color = "#c2cdd8")

plt.title("1% Death risk comparizon")
plt.legend()
plt.xlabel("Days since 30 January 2020")
plt.ylabel("Cases")
plt.xlim(30, max(x) * 1.01)
plt.ylim(0, max(y) * 1.05)
plt.show()
print("Expected actual value is: " + str(max(y)) + " in day " + str(max(x)))
```


```
Expected actual value is: 420500 in day 87
```

2.2 Casos Totais por estado

Casos confirmados x tempo

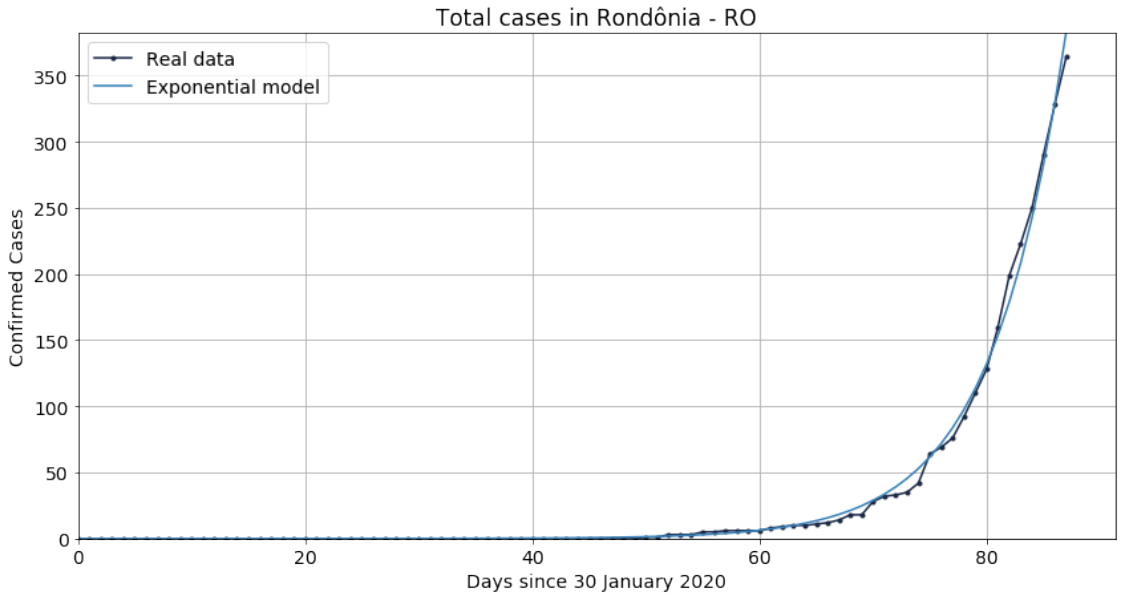
Dados reais, estimativa exponencial e em estados com mais de 1000 casos estimativa logistica

Os dados são subnotificados e possuem baixa confiabilidade

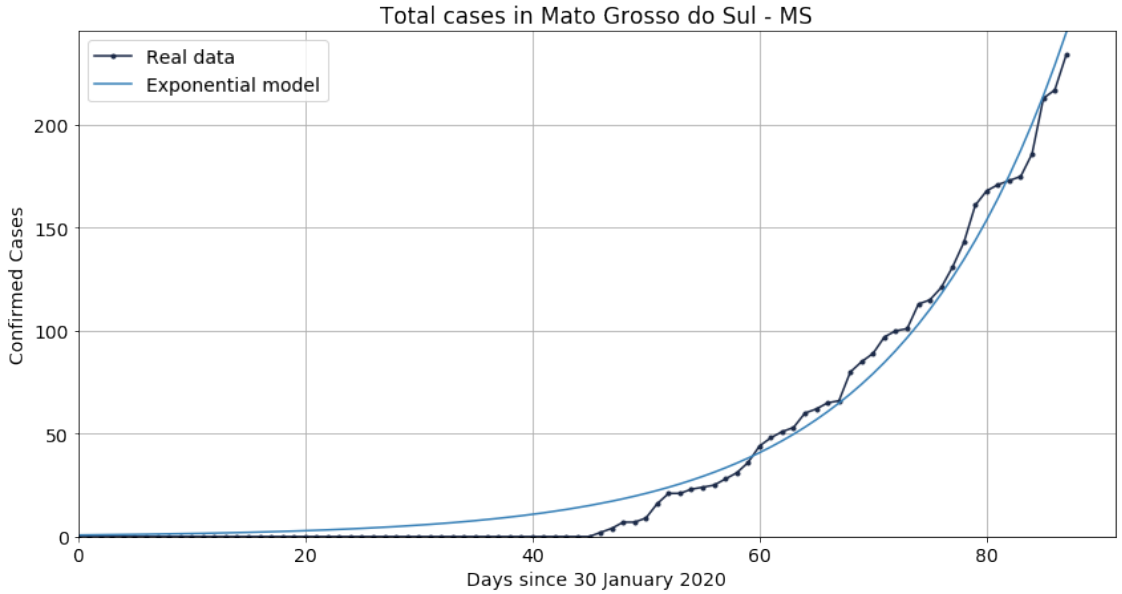
[26]:
```
plt.grid(True)
plt.rcParams['figure.figsize'] = [14, 7]

estados = dfs["estado"].unique()

for e in estados :
    df_e = df_UF.loc[df_UF.iloc[:,0] == e, :].iloc[:, [1, 2]]
    pop = brasil.at[brasil['UF'].eq(e).idxmax(),'População']
    uf = brasil.at[brasil['UF'].eq(e).idxmax(), "Unidade da Federação"]
    x = list(df_e.iloc[:, 0])
    y = list(df_e.iloc[:, 1])

    plt.grid(True)
    plt.rcParams['figure.figsize'] = [14, 7]

    # Real data
    plt.plot(x, y, marker = '.', label = "Real data", color = "#1d2b49")

    exponential_fit = curve_fit(exponential_model, x, y, p0 = [1, 1, 1], bounds␣
↪= (0, df_e.index.size))
    exponential_sol = int(fsolve(lambda x : exponential_model(x,␣
↪exponential_fit[0][0], exponential_fit[0][1],
                                                              ␣
↪exponential_fit[0][2]) - int(exponential_fit[0][2]), exponential_fit[0][1]))

    if max(y) > 1000 :
        logistic_fit = curve_fit(logistic_model, x, y, p0 = [a0, b0, 0.4 * pop])
        logistic_sol = int(fsolve(lambda x : logistic_model(x,␣
↪logistic_fit[0][0], logistic_fit[0][1],
                                                            logistic_fit[0][2])␣
↪- int(logistic_fit[0][2]), logistic_fit[0][1]))

        pred_x = list(range(max(x), logistic_sol))

        # Predicted logistic curve
        plt.plot(x + pred_x, [logistic_model(i, logistic_fit[0][0],␣
↪logistic_fit[0][1], logistic_fit[0][2])
                              for i in x + pred_x], label = "Logistic model",␣
↪color = "#c2cdd8")
```

```
        plt.xlim(0, max(pred_x) * 1.05)
        plt.ylim(0, logistic_fit[0][2] * 1.05)
        print("Expected final values: end of spread in " + str(max(pred_x)) + "␣
↪days with " + str(round(logistic_fit[0][2], 3)) + " cases in " + e)

    else :
        plt.xlim(0, max(x) * 1.05)
        plt.ylim(0, max(y) * 1.05)

    # Predicted exponential curve
    plt.plot(x + pred_x, [exponential_model(i, exponential_fit[0][0],␣
↪exponential_fit[0][1], exponential_fit[0][2])
                          for i in x + pred_x], label = "Exponential model",␣
↪color = "#3881b8")

    print("Next number of confirmed is "+ str(round(exponential_model(max(x) +␣
↪1, exponential_fit[0][0], exponential_fit[0][1], exponential_fit[0][2]), 3))␣
↪+ " in " + e)

    plt.title("Total cases in " + uf + ' - ' + e)
    plt.legend()
    plt.xlabel("Days since 30 January 2020")
    plt.ylabel("Confirmed Cases")
    plt.show()
```

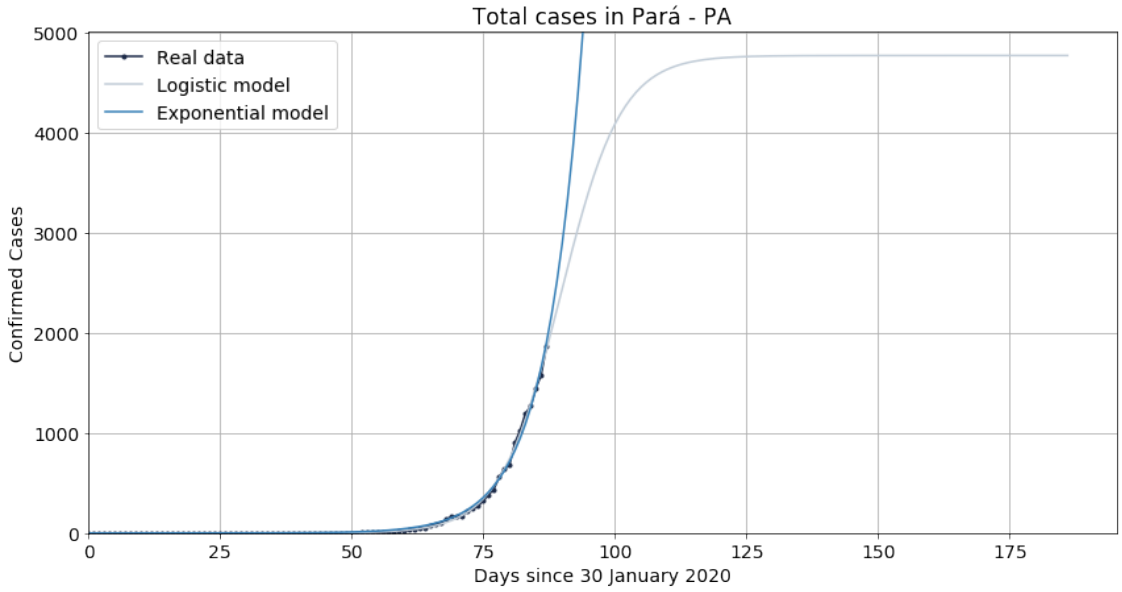
```
Next number of confirmed is 445.849 in RO
```



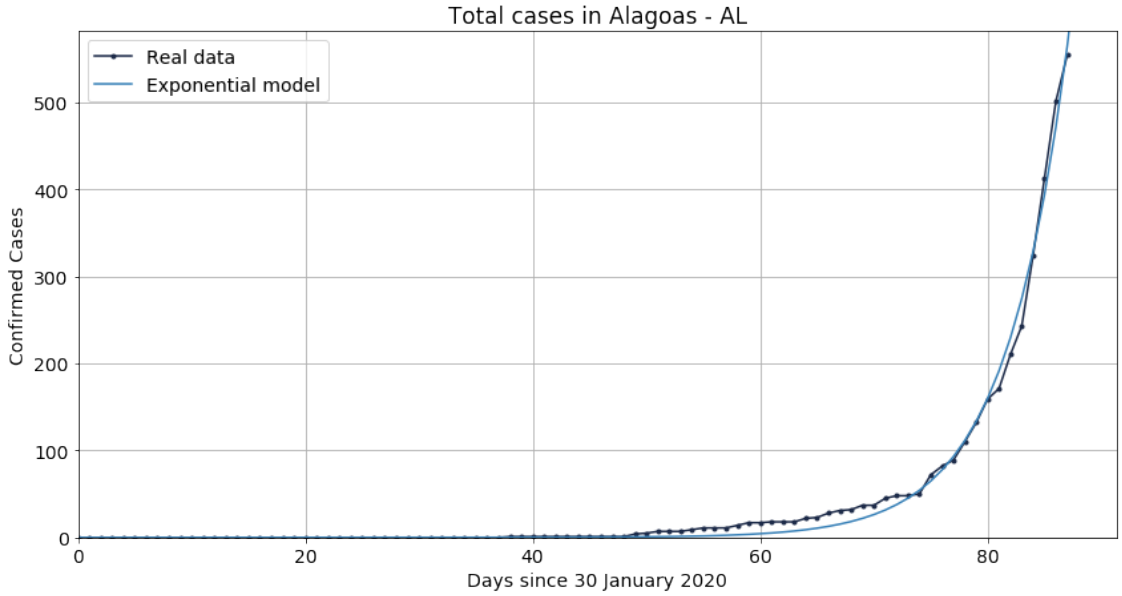
```
Next number of confirmed is 261.589 in MS
```



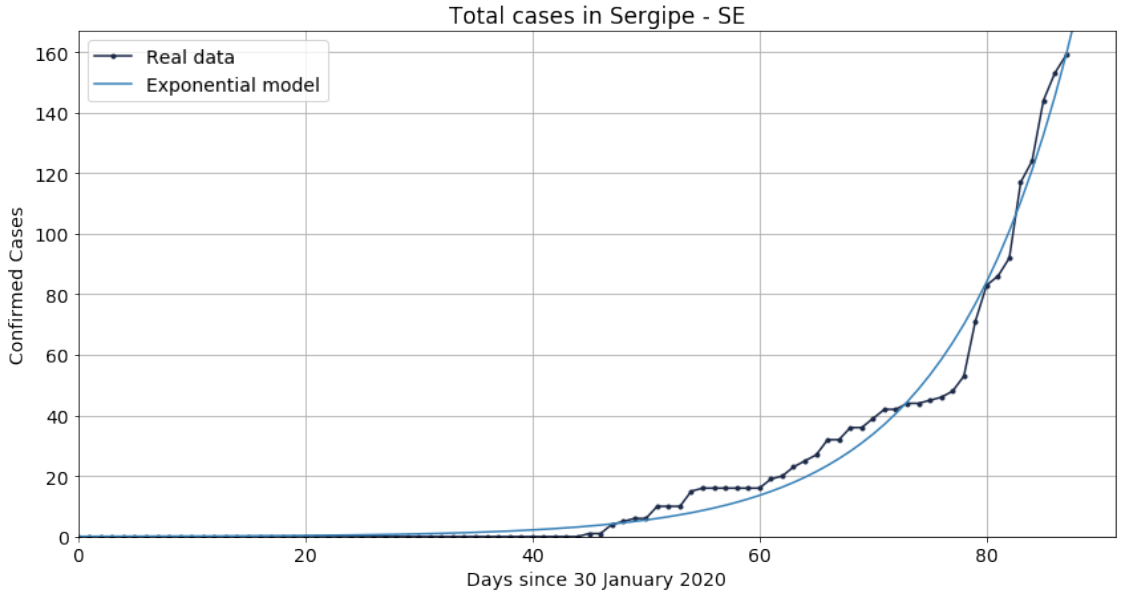

```
Expected final values: end of spread in 186 days with 4768.0 cases in PA
Next number of confirmed is 2189.339 in PA
```



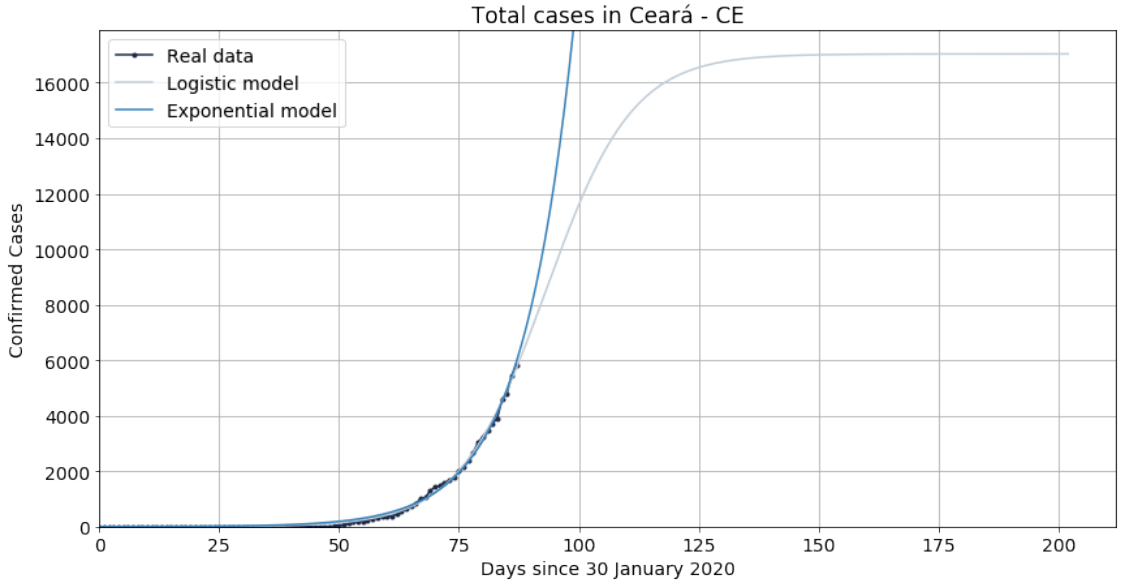

```
Next number of confirmed is 675.838 in AL
```



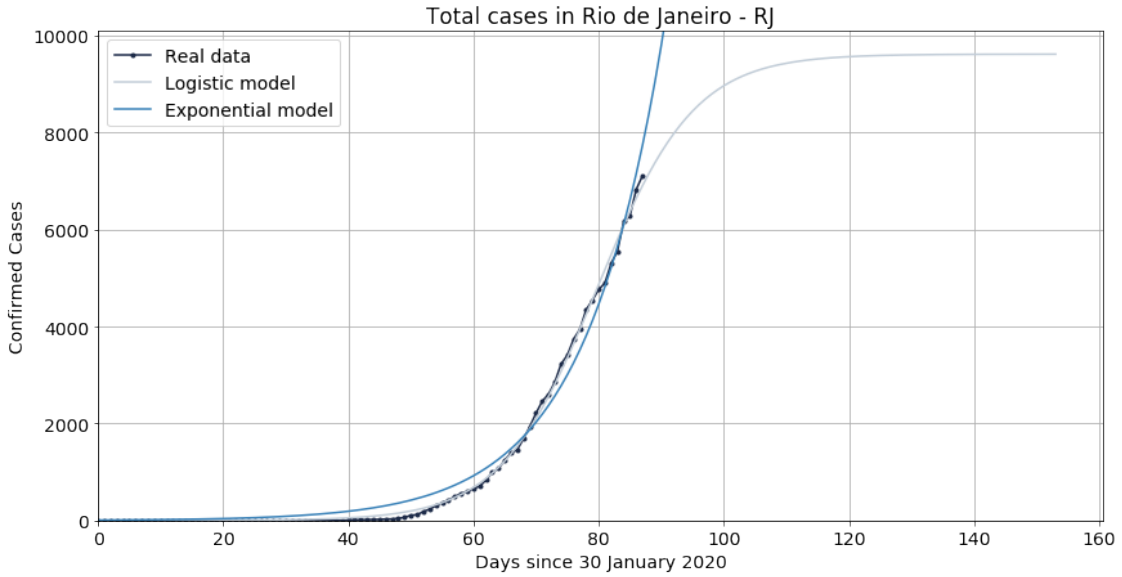

```
Next number of confirmed is 174.252 in SE
```



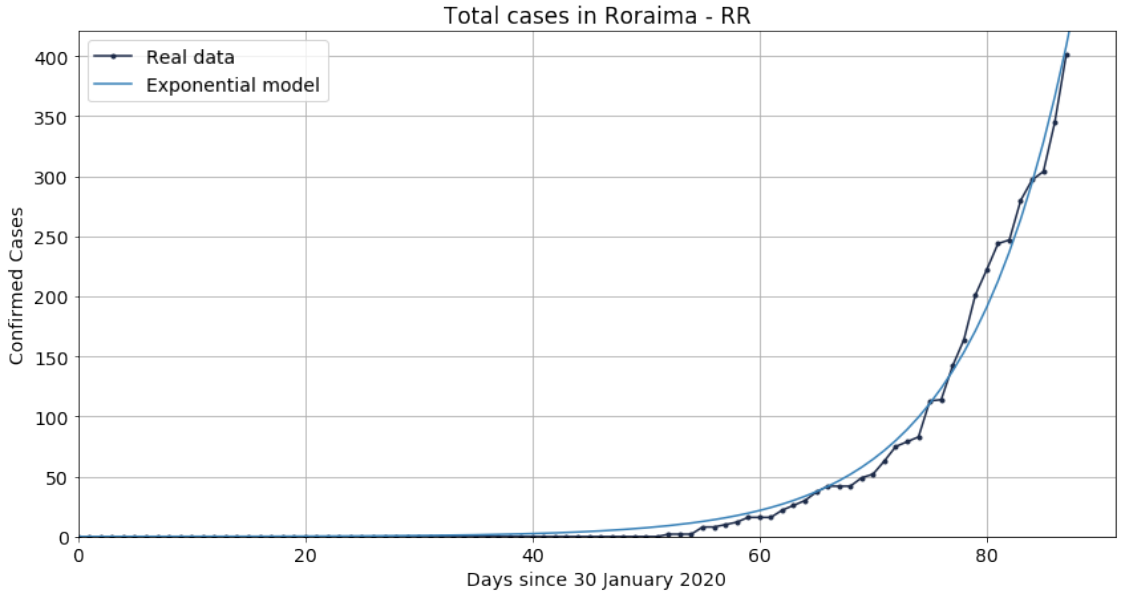

```
Expected final values: end of spread in 202 days with 17037.088 cases in CE
Next number of confirmed is 6529.52 in CE
```



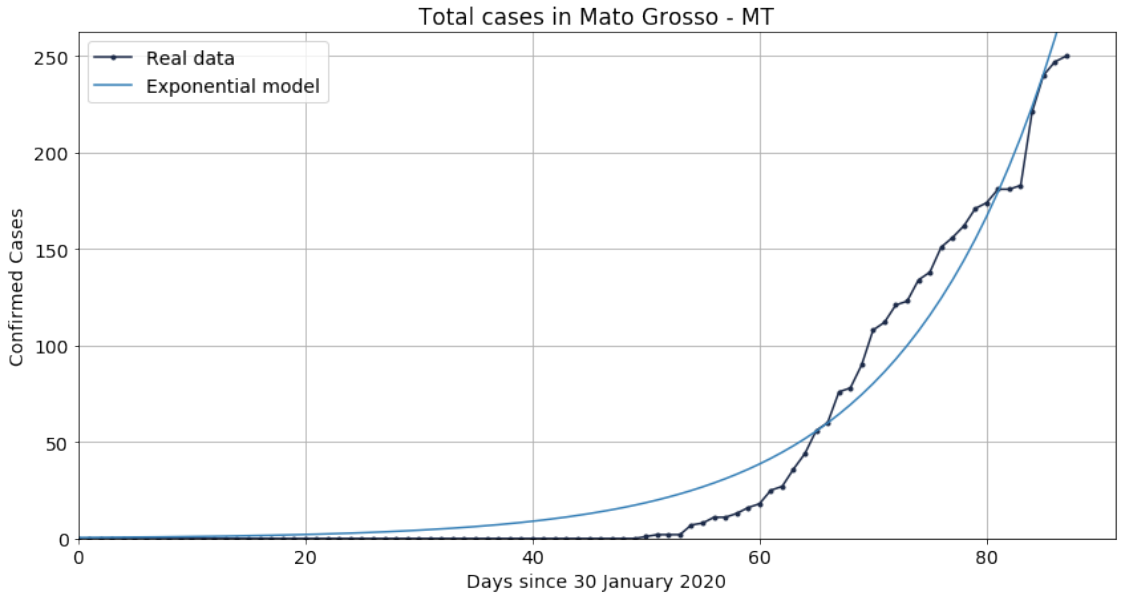

```
Expected final values: end of spread in 153 days with 9618.584 cases in RJ
Next number of confirmed is 8369.897 in RJ
```



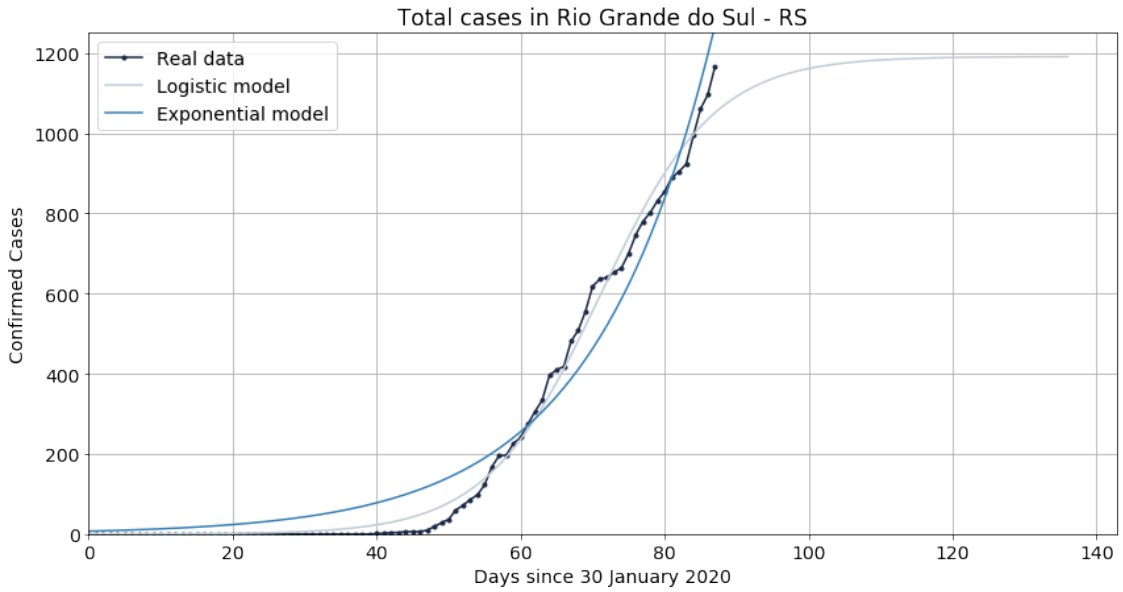

```
Next number of confirmed is 455.067 in RR
```



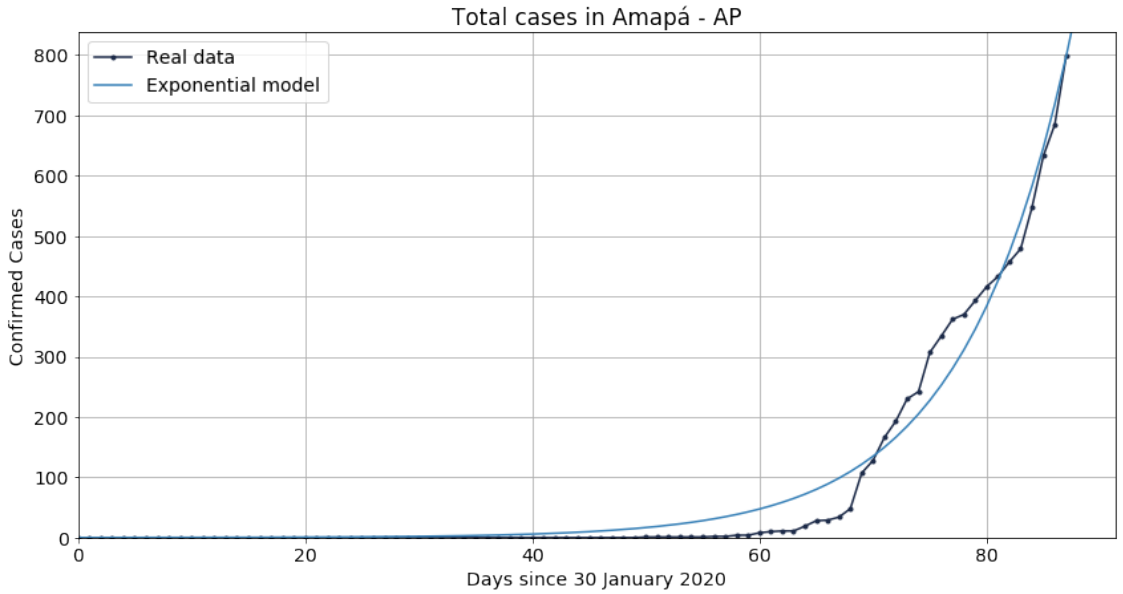

```
Next number of confirmed is 299.877 in MT
```



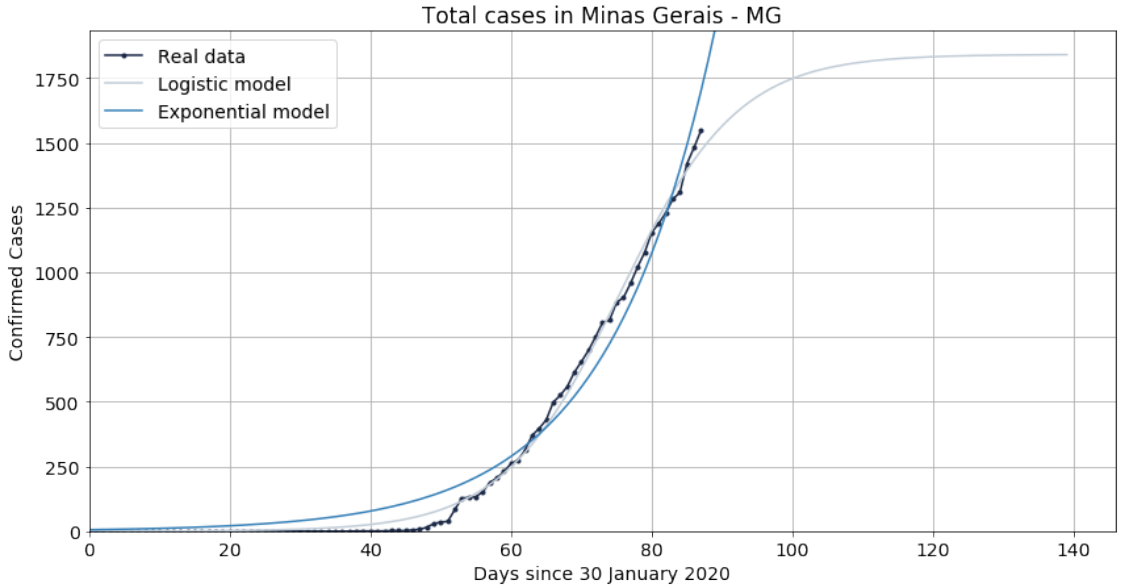

```
Expected final values: end of spread in 136 days with 1191.265 cases in RS
Next number of confirmed is 1346.328 in RS
```



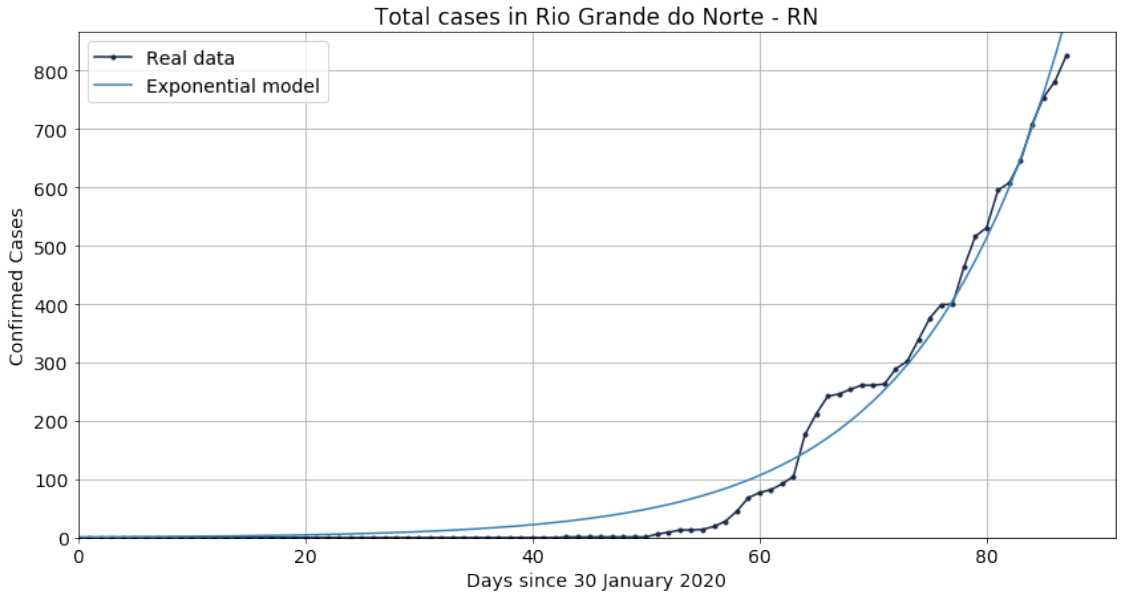

```
Next number of confirmed is 885.667 in AP
```



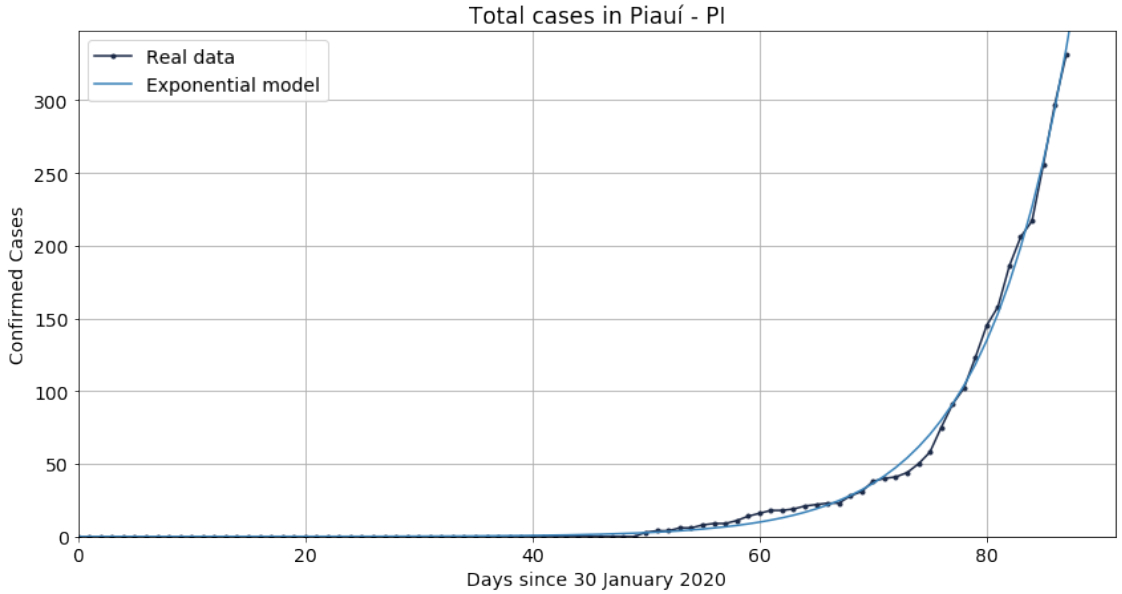

```
Expected final values: end of spread in 139 days with 1841.792 cases in MG
Next number of confirmed is 1815.465 in MG
```



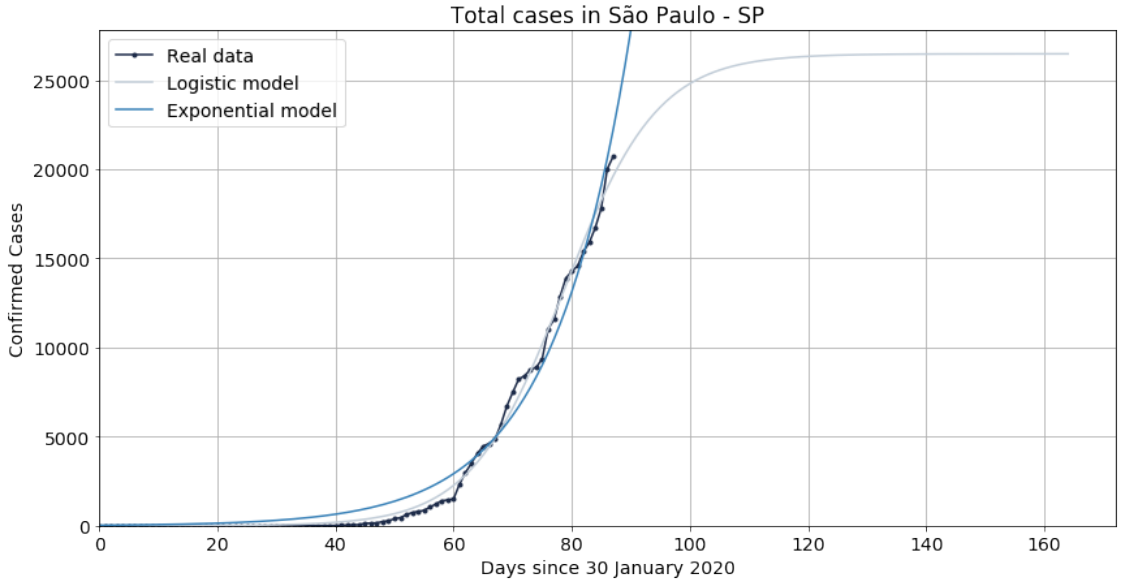

```
Next number of confirmed is 963.111 in RN
```



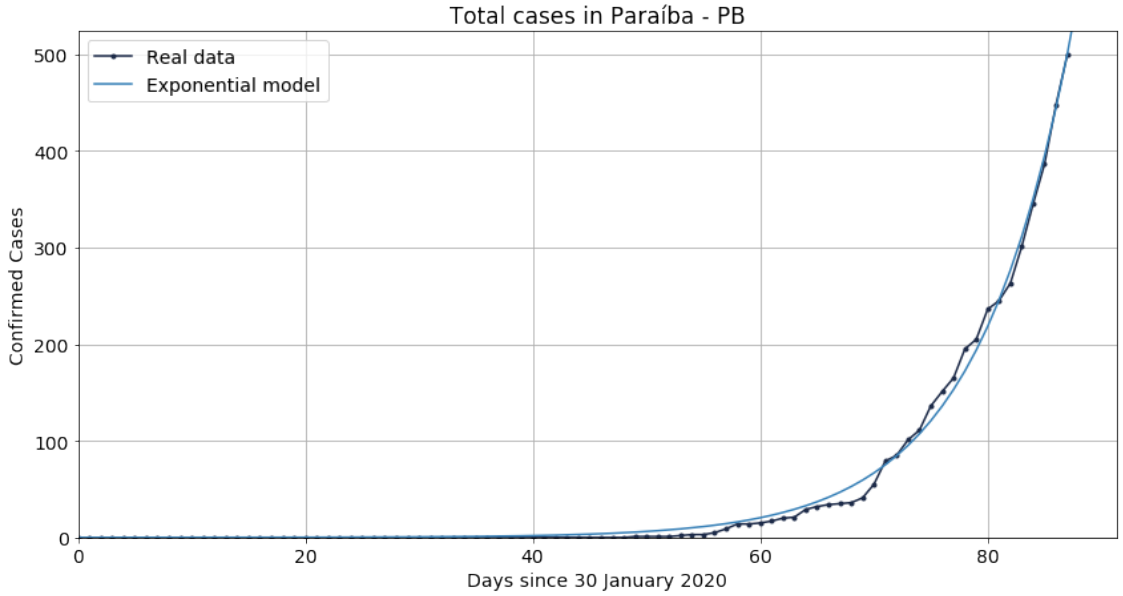

```
Next number of confirmed is 381.781 in PI
```



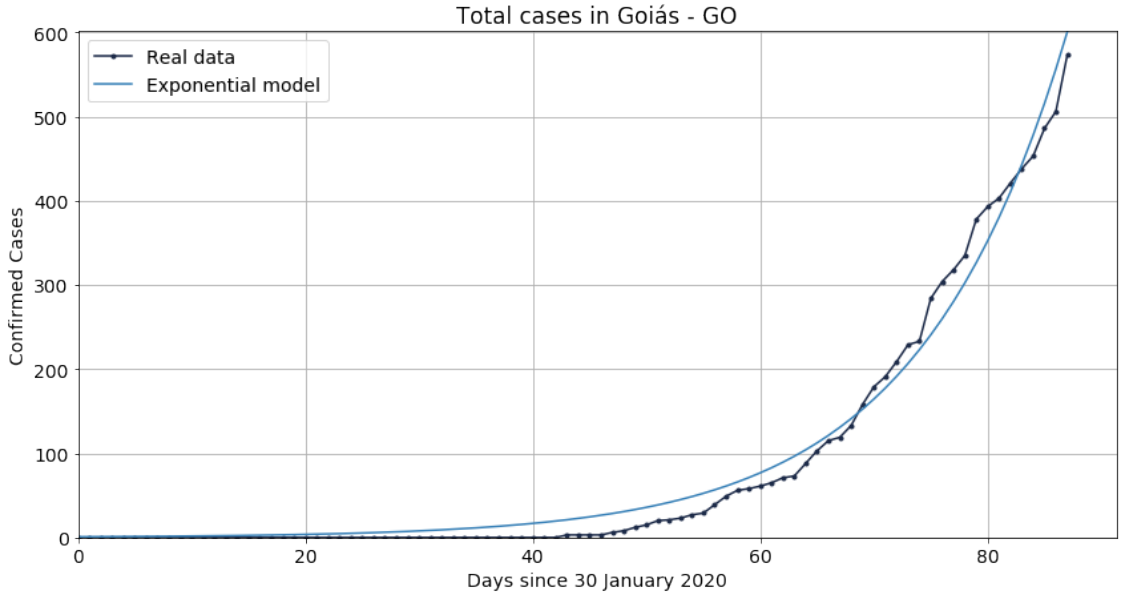

```
Expected final values: end of spread in 164 days with 26472.426 cases in SP
Next number of confirmed is 23933.19 in SP
```



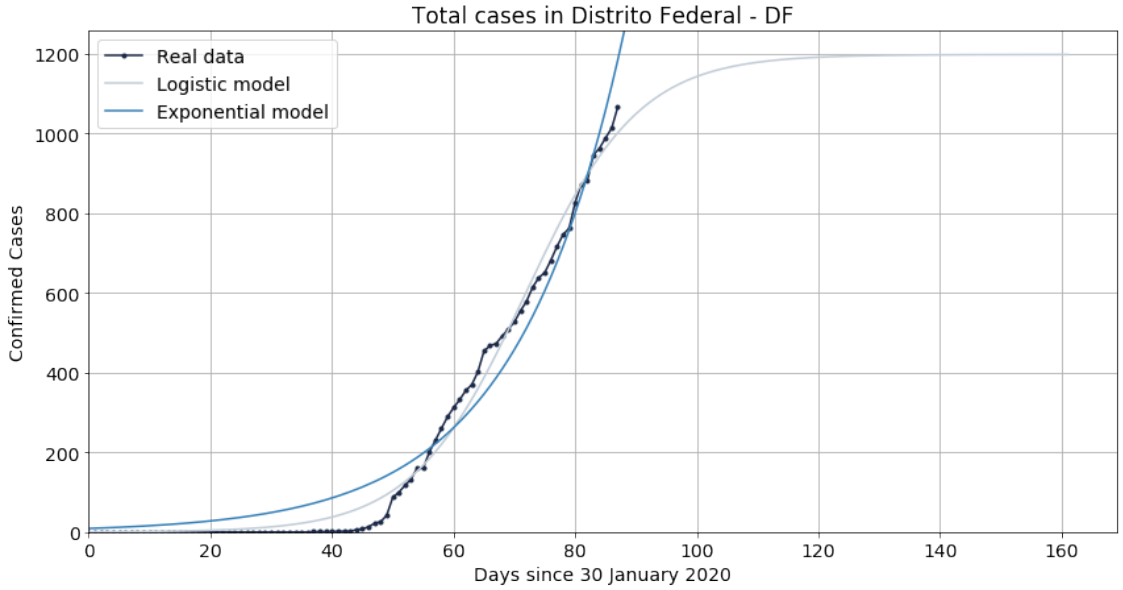

```
Next number of confirmed is 562.787 in PB
```



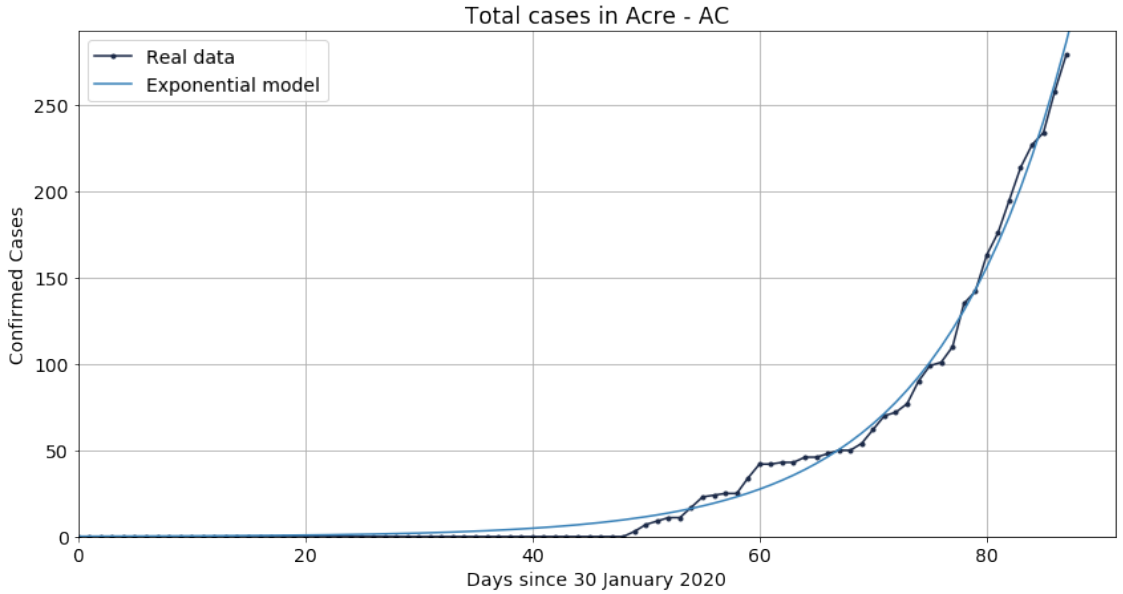

```
Next number of confirmed is 647.985 in GO
```



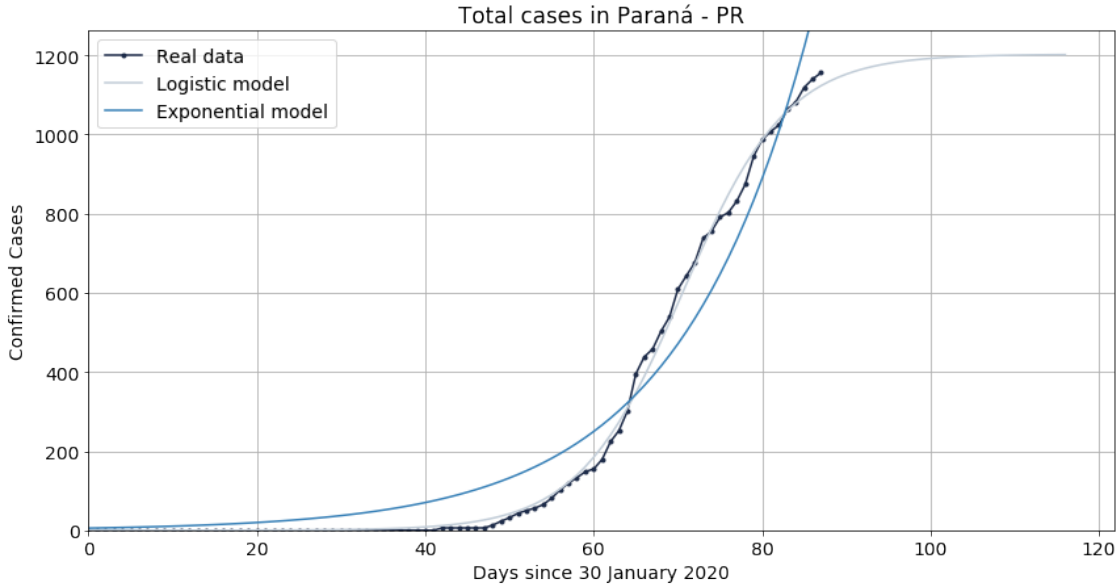

```
Expected final values: end of spread in 161 days with 1198.066 cases in DF
Next number of confirmed is 1252.089 in DF
```



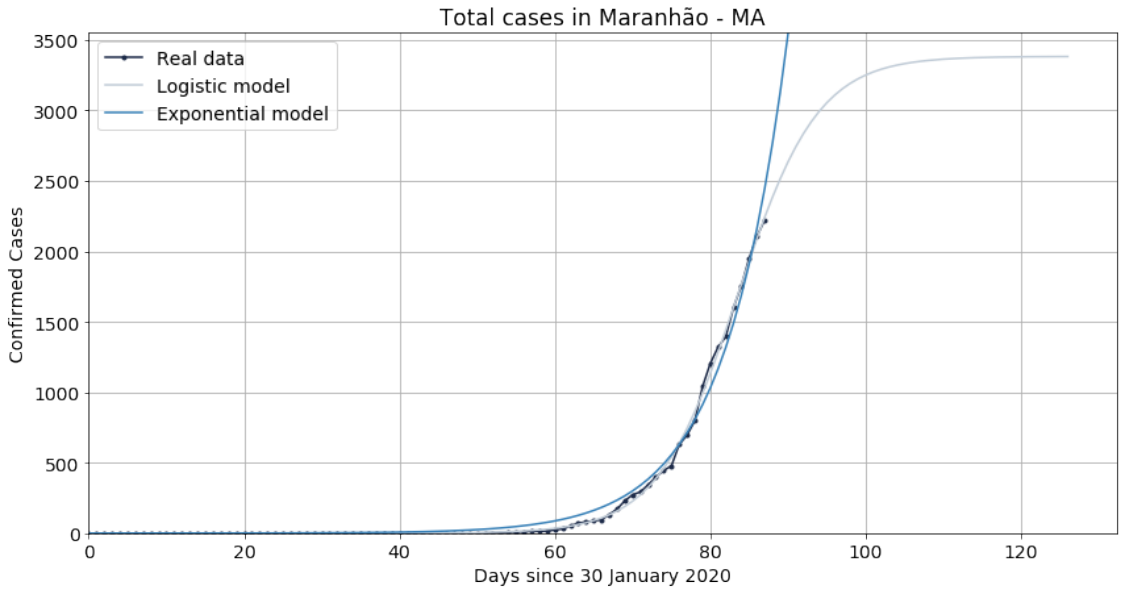

```
Next number of confirmed is 312.265 in AC
```



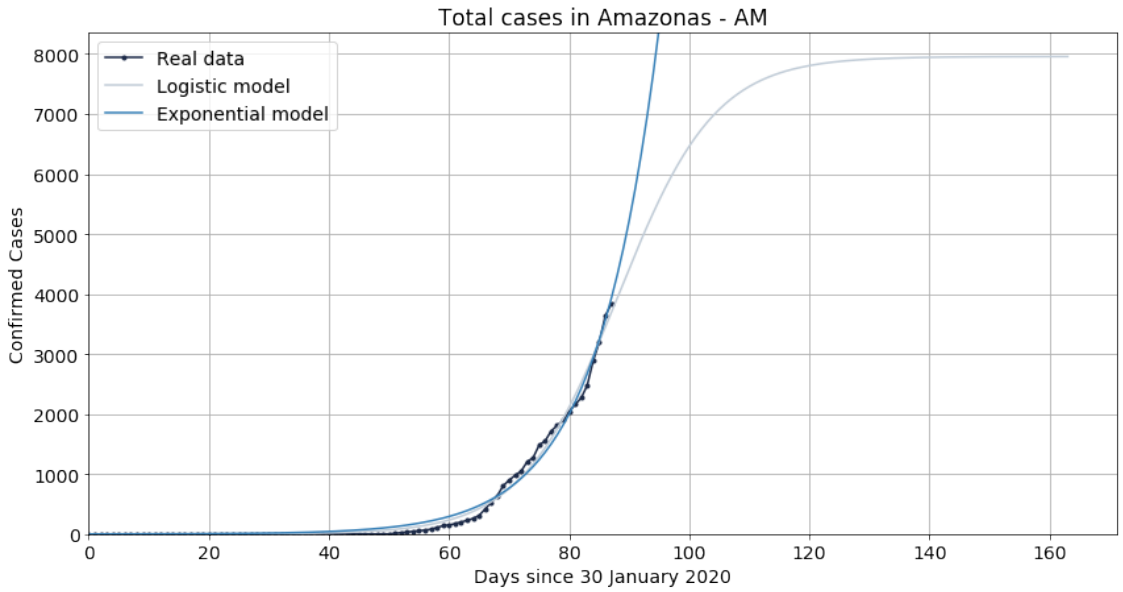

```
Expected final values: end of spread in 116 days with 1202.58 cases in PR
Next number of confirmed is 1476.444 in PR
```



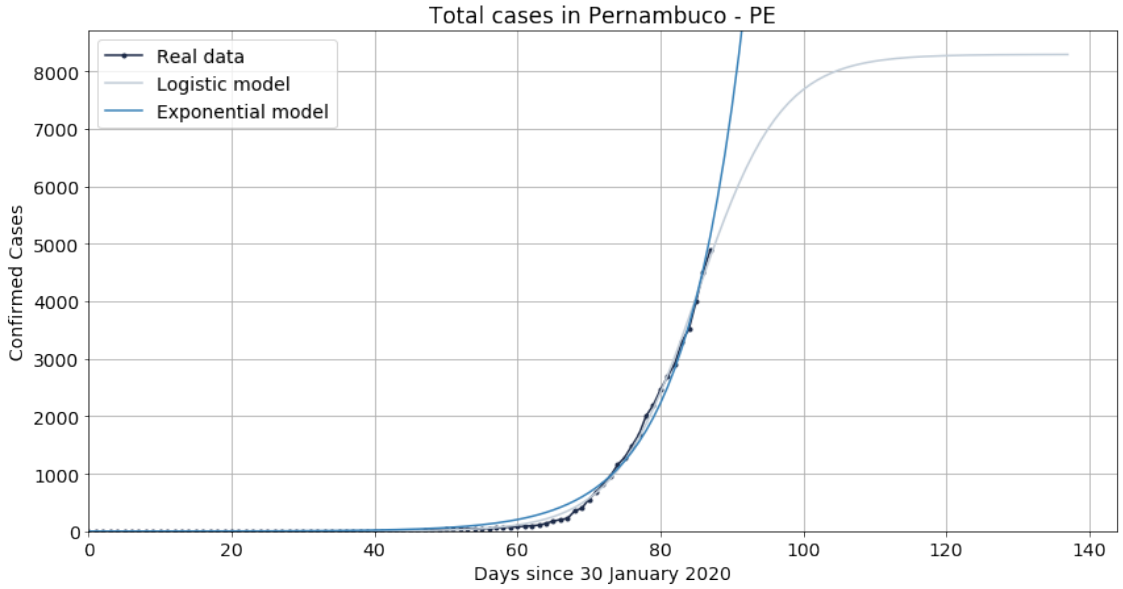

```
Expected final values: end of spread in 126 days with 3383.699 cases in MA
Next number of confirmed is 2766.736 in MA
```



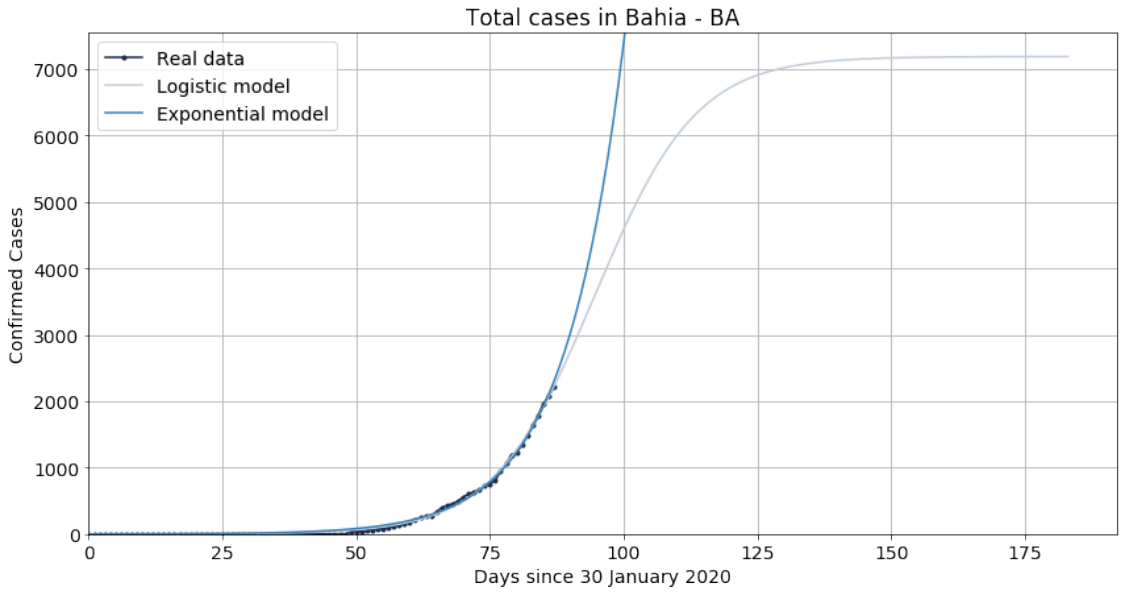

```
Expected final values: end of spread in 163 days with 7957.592 cases in AM
Next number of confirmed is 4317.677 in AM
```



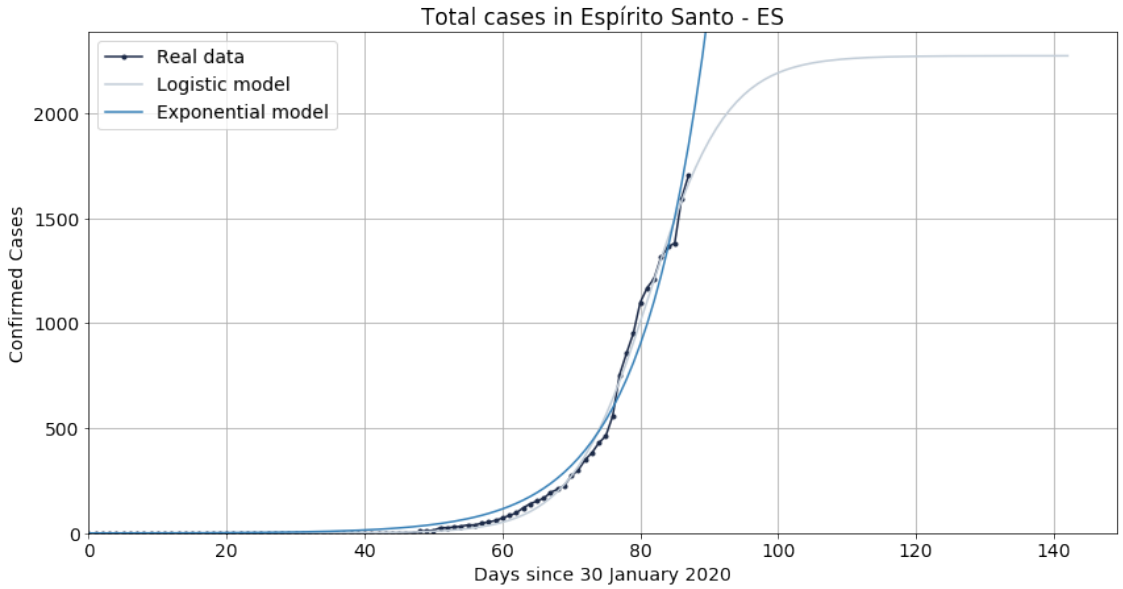

```
Expected final values: end of spread in 137 days with 8293.839 cases in PE
Next number of confirmed is 5798.755 in PE
```



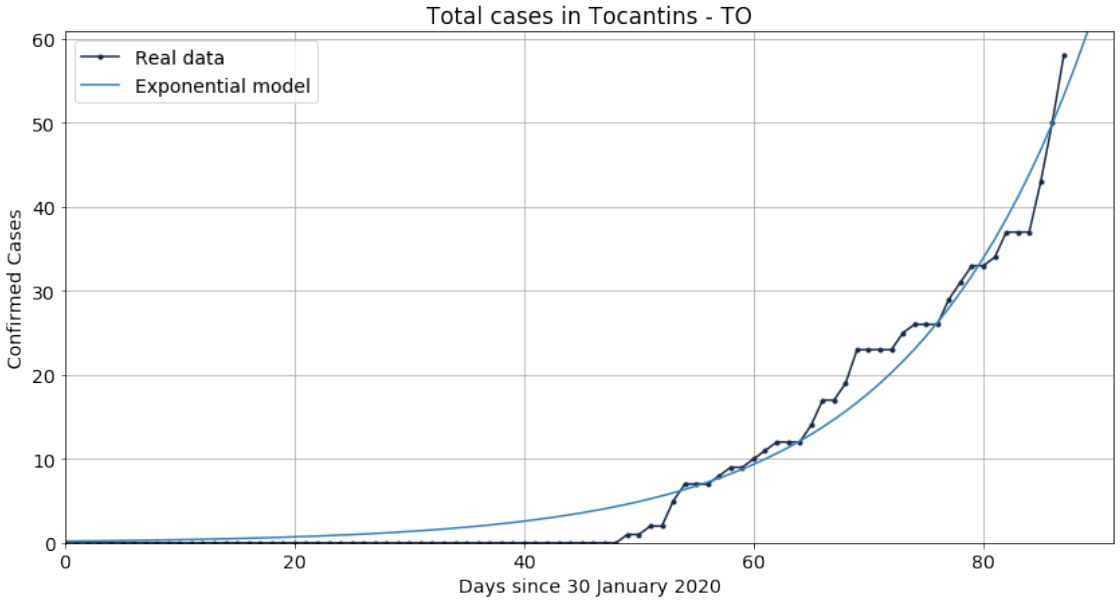

```
Expected final values: end of spread in 183 days with 7189.584 cases in BA
Next number of confirmed is 2523.237 in BA
```



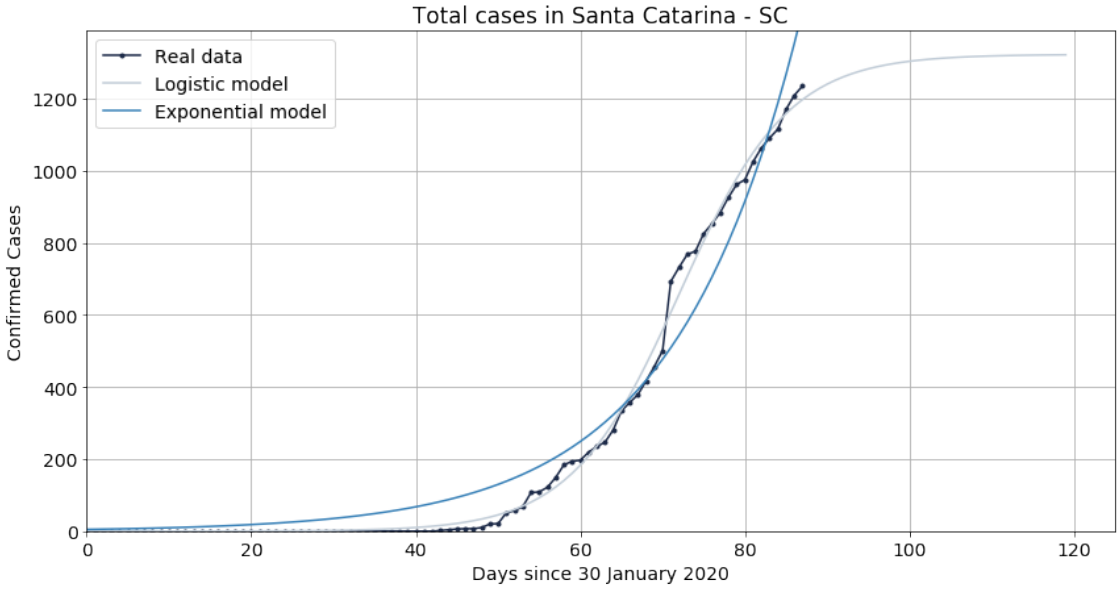

```
Expected final values: end of spread in 142 days with 2273.04 cases in ES
Next number of confirmed is 2045.635 in ES
```




```
Next number of confirmed is 56.762 in TO
```




```
Expected final values: end of spread in 119 days with 1322.836 cases in SC
Next number of confirmed is 1540.124 in SC
```



2.3 New Features

[ ]:
```
#debugging

est = 'SP'

df_PE = df_UF.loc[df_UF.iloc[:,0] == est, :].iloc[:, [1, 2]]
pop = brasil.at[brasil['UF'].eq(est).idxmax(),'População']
y = list(df_PE.iloc[:, 1])

plt.grid(True)

# Real data
plt.plot(x, y, marker = '.', label = "Real data", color = "#1d2b49")

exponential_fit = curve_fit(exponential_model, x, y, p0 = [1, 1, 1], bounds =␣
↪(0, df.index.size))
exponential_sol = int(fsolve(lambda x : exponential_model(x,␣
↪exponential_fit[0][0], exponential_fit[0][1],
                                                          ␣
↪exponential_fit[0][2]) - int(exponential_fit[0][2]), exponential_fit[0][1]))

logistic_fit = curve_fit(logistic_model, x, y, p0 = [a0, b0, 0.4 * pop])
logistic_sol = int(fsolve(lambda x : logistic_model(x, logistic_fit[0][0],␣
↪logistic_fit[0][1],
                                                    logistic_fit[0][2]) -␣
↪int(logistic_fit[0][2]), logistic_fit[0][1]))

pred_x = list(range(max(x), logistic_sol))

# Predicted logistic curve
plt.plot(x + pred_x, [logistic_model(i, logistic_fit[0][0], logistic_fit[0][1],␣
↪logistic_fit[0][2])
                      for i in x + pred_x], label = "Logistic model", color =␣
↪"#c2cdd8")

# Logistic errors
# plt.plot(x + pred_x, [logistic_model(i, logistic_fit[0][0] + np.
↪sqrt(logistic_fit[1][0][0]),
#                                      logistic_fit[0][1] + np.
↪sqrt(logistic_fit[1][1][1]),
#                                      logistic_fit[0][2] + np.
↪sqrt(logistic_fit[1][2][2]))
#                       for i in x + pred_x], label = "Logistic model max",␣
↪color = "#ee5907")
```

```
# plt.plot(x + pred_x, [logistic_model(i, logistic_fit[0][0] - np.
 ↪sqrt(logistic_fit[1][0][0]),
#                                     logistic_fit[0][1] - np.
 ↪sqrt(logistic_fit[1][1][1]),
#                                     logistic_fit[0][2] - np.
 ↪sqrt(logistic_fit[1][2][2]))
#                         for i in x + pred_x], label = "Logistic model min",␣
 ↪color = "#66983f")


# Predicted exponential curve
plt.plot(x + pred_x, [exponential_model(i, exponential_fit[0][0],␣
 ↪exponential_fit[0][1], exponential_fit[0][2])
                      for i in x + pred_x], label = "Exponential model", color␣
 ↪= "#3881b8")
exponential_errors = [np.sqrt(exponential_fit[1][i][i]) for i in [0, 1, 2]]

# Exponential errors

# plt.plot(x + pred_x, [exponential_model(i, exponential_fit[0][0] + np.
 ↪sqrt(exponential_fit[1][0][0]),
#                                     exponential_fit[0][1] + np.
 ↪sqrt(exponential_fit[1][1][1]),
#                                     exponential_fit[0][2] + np.
 ↪sqrt(exponential_fit[1][2][2]))
#                         for i in x + pred_x], label = "Logistic model max",␣
 ↪color = "#ee5907")

# plt.plot(x + pred_x, [exponential_model(i, logistic_fit[0][0] - np.
 ↪sqrt(exponential_fit[1][0][0]),
#                                     exponential_fit[0][1] - np.
 ↪sqrt(exponential_fit[1][1][1]),
#                                     exponential_fit[0][2] - np.
 ↪sqrt(exponential_fit[1][2][2]))
#                         for i in x + pred_x], label = "Exponential model min",␣
 ↪color = "#66983f")

plt.title("Total cases in " + brasil.at[brasil['UF'].eq(est).idxmax(), "Unidade␣
 ↪da Federação"])
plt.legend()
plt.xlabel("Days since 30 January 2020")
plt.ylabel("Cases")
plt.ylim(0, (logistic_fit[0][2] + np.sqrt(logistic_fit[1][2][2])) * 1.05)
plt.show()
print(exponential_errors)
```

[ ]: