Project 2 - Coronavirus

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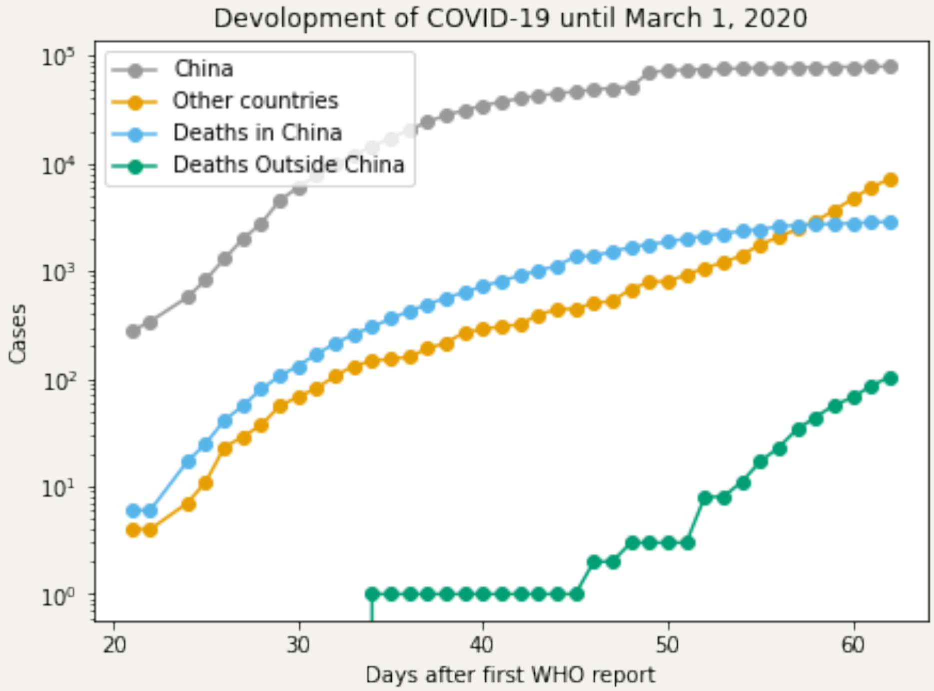
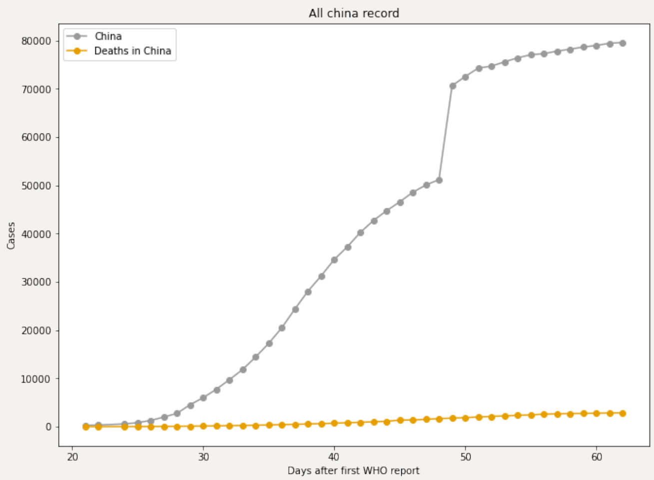
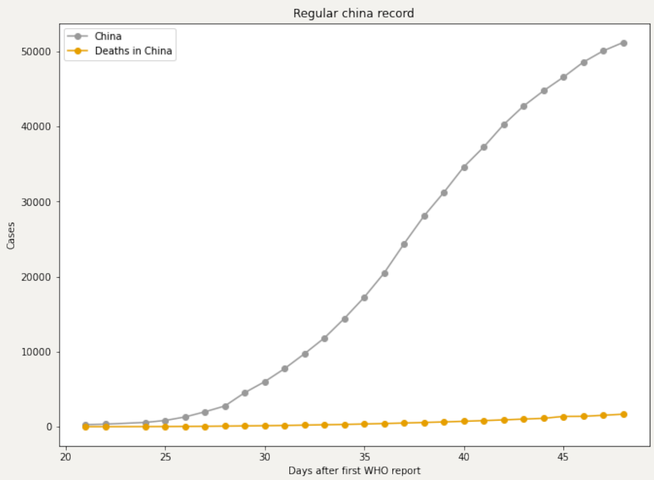
Introduction



In the context of an epidemi and data era we want to use mathematical tools to model what the outcome might be. The image at the top is the information of cases and deaths (in china and in the rest of the world) vs days after the first WHO report.

We will focus on the trends of china.





The problem with this data is that there is an abrupt jump. If we plan to use diferential equations to understand the phenomena we can have this values. That is why we consider just the regular part (from day 21 to 41).

Mathematical model

Using known models for epidemiology we want to make inferences or conlcusions. We use a SIR mode:

$$\frac{\mathrm{d}S}{\mathrm{d}t} = -\beta \frac{SI}{N}$$
$$\frac{\mathrm{d}I}{\mathrm{d}t} = \beta \frac{SI}{N} - \gamma I$$
$$\frac{\mathrm{d}R}{\mathrm{d}t} = \gamma I$$

Susceptible -> Infected -> Recovered. (In this case, recovered is death.)

$\beta = \text{Contact Rate} \ \times \ \text{Probability of Transmission}$
$\gamma = \text{Recovery Rate}$

To simplfy the system notice how

$$\frac{\mathrm{d}S}{\mathrm{d}t} + \frac{\mathrm{d}R}{\mathrm{d}t} + \frac{\mathrm{d}I}{\mathrm{d}t} = 0$$

That means the amount of populations is constant over the days, say a population N . And $N = S + I + R$. So we can reduce our system of equations by changing $S = N - (I + R)$. Now the system is:

$$\frac{\mathrm{d}I}{\mathrm{d}t} = \beta \frac{(N - (I + R))I}{N} - \gamma I$$
$$\frac{\mathrm{d}R}{\mathrm{d}t} = \gamma I$$

Even more, we will consider the initial conditions to be $I(0) = 1$ y $R(0) = 1$.

Now the problem is in terms of the number of cases and the number of deaths.

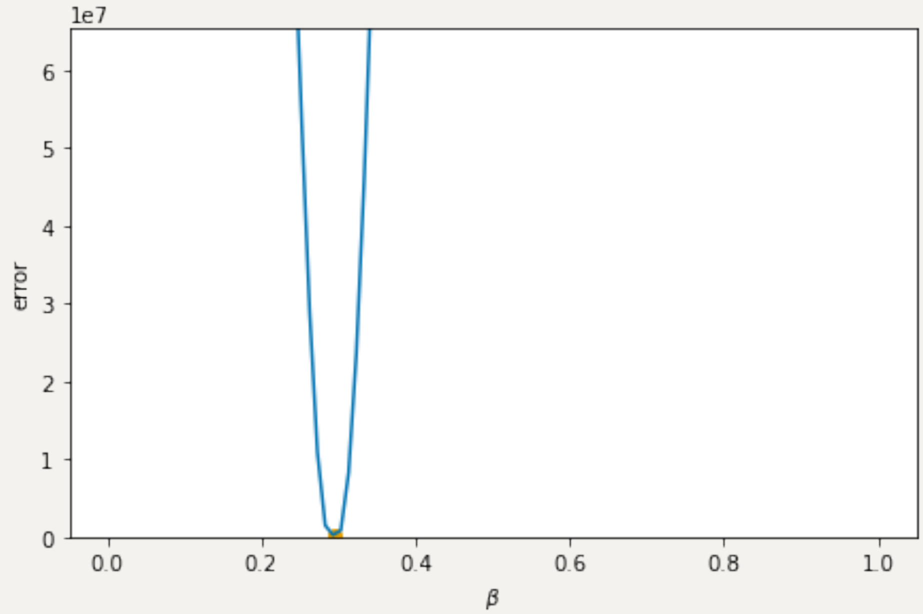
We will use the PDEparams library to have an approx of parameters.

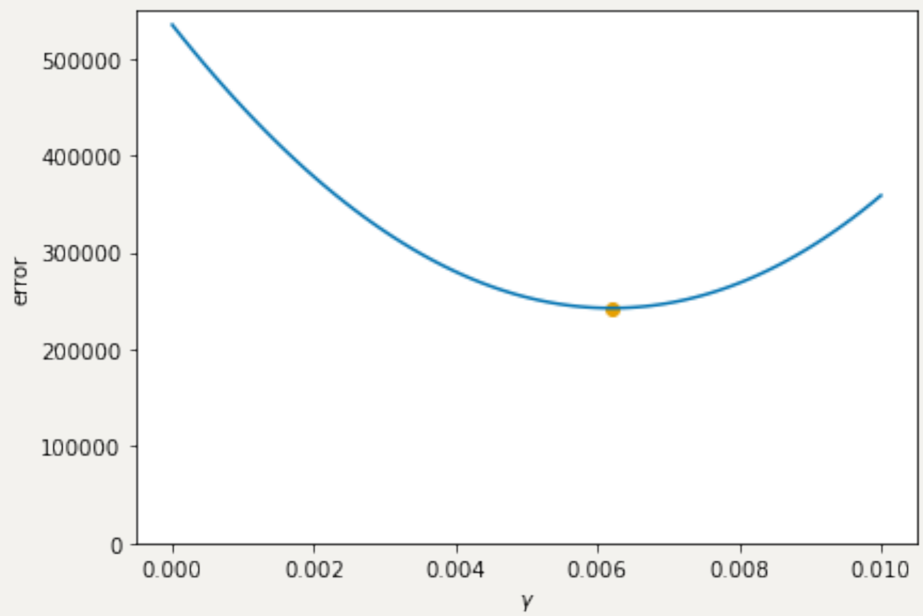
Results

We will consider diffent scenarios and see how well this performs or what does it tell us.

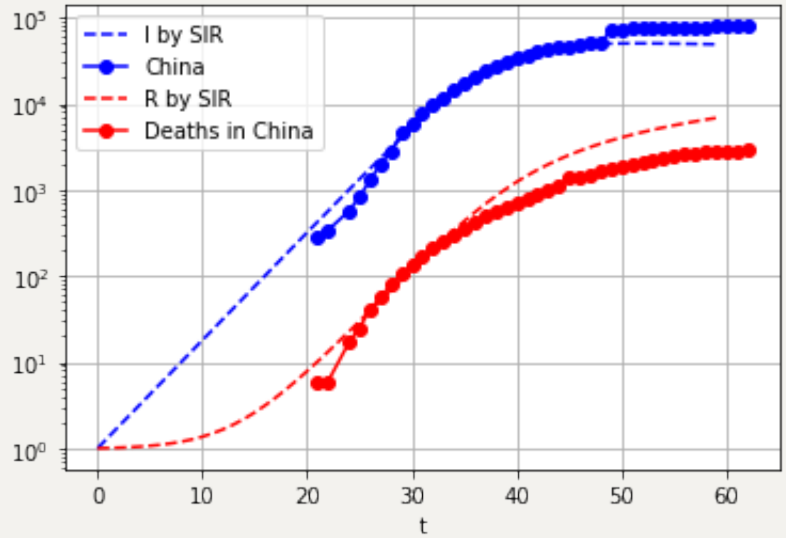
Regular part and $N = 56 \times 10^3$

Our best parameter are $\beta = 0.2949$ and $\gamma = 0.0062$. With an squared error of 242497.15284 . Given the likelihood profiles is quite clear this are the minimum points.

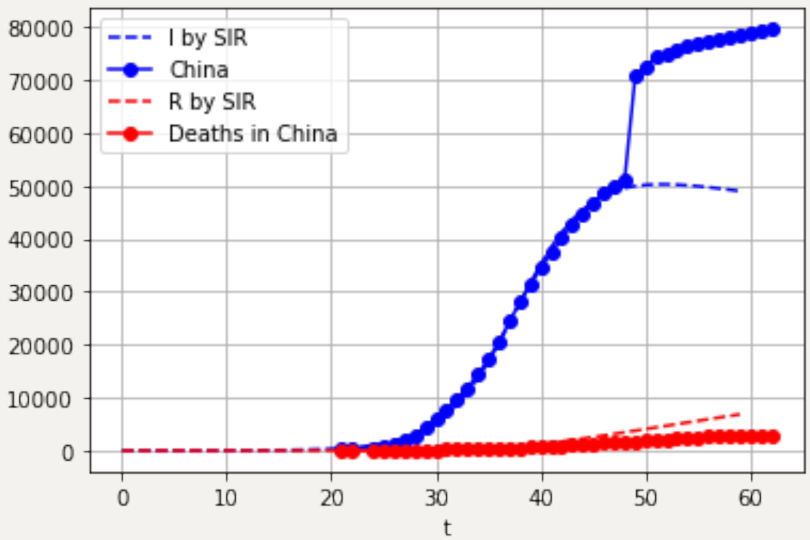




By comparing the interactions in log scale with the real system we see cualitative similarity:

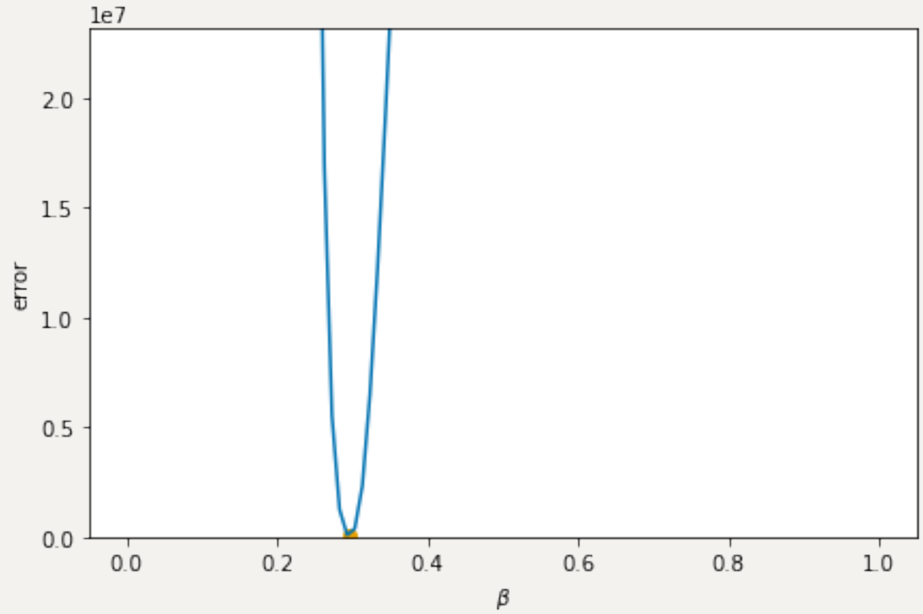


but is evident that the SIR trend broke at some point

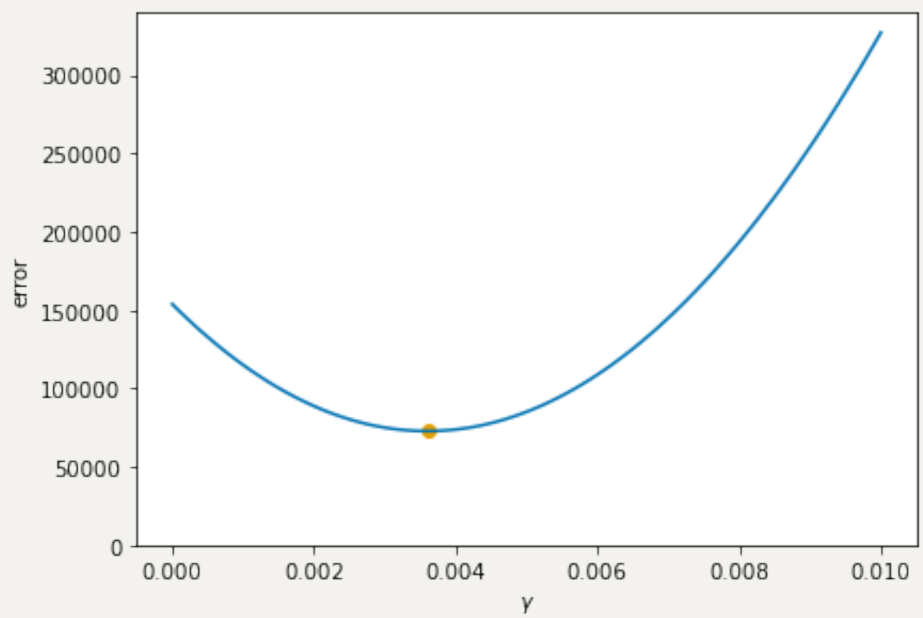


Regular part and stimating N

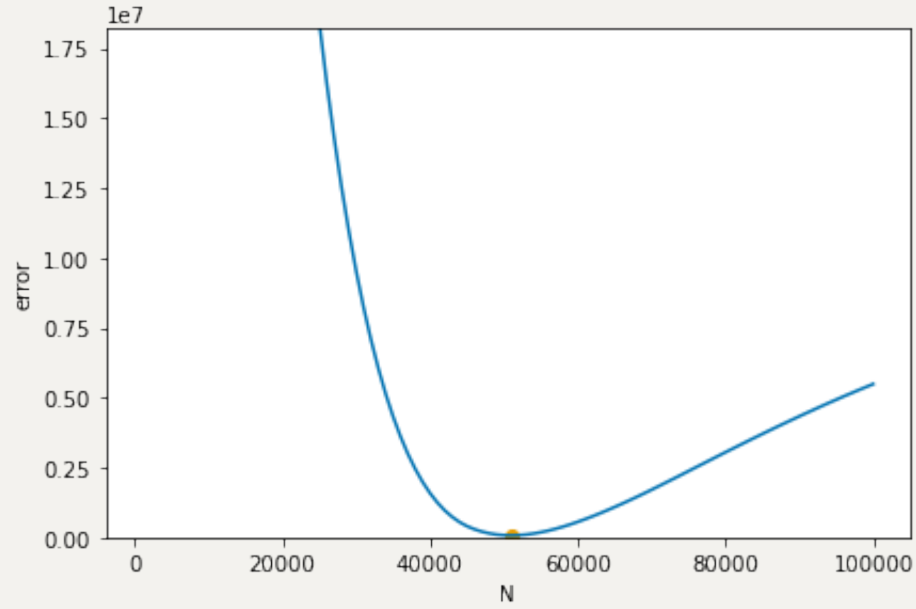
We got similar results. $\beta = 0.295$, $\gamma = 0.0036$ y $N = 50985.42$. And is clear they minimize:



1e7
2.0
1.5
1.0
0.5
0.0
error
0.0
0.2
0.4
0.6
0.8
1.0
β

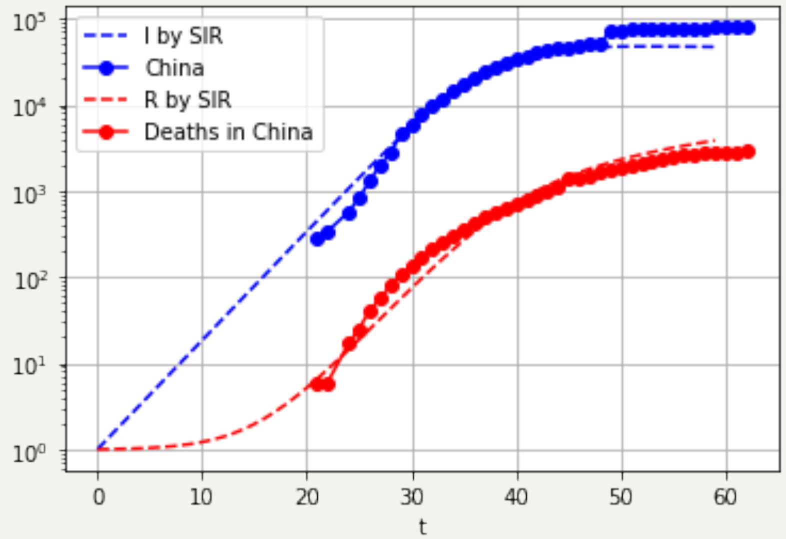


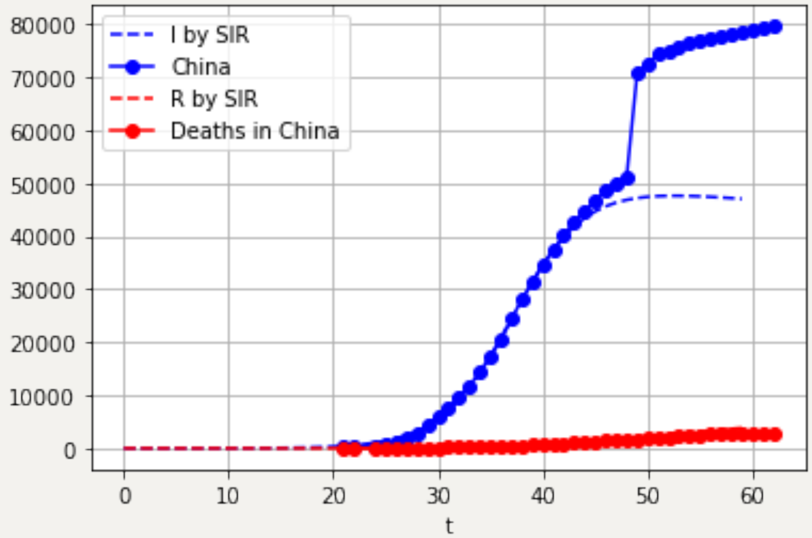
300000
250000
200000
150000
100000
50000
0
error
0.000
0.002
0.004
0.006
0.008
0.010
γ



And the quadratic error is less than before: 72802.863.

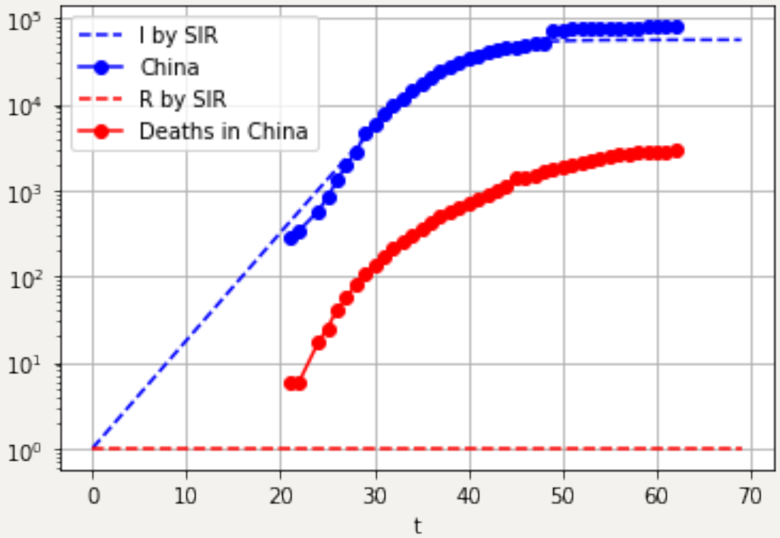
The cualitative apreciations are similar.





The Problem of considering all the data:

We also try to fit to the model the whole data, the results aren't as good.



We have consistency of the value of β but the fit says $\gamma = 0$ which it doesn't apply to real life.

Conclusions

Models like ODE are largely study and they contain a lot of information about what is happening to the system. But in order to applied we need to check that our phenomena is consistent with our model. In this case the discontinuity breaks our model. Apart from that it has been show how importat is Machine learning to improve even the clasic models.