Climate Change Calculated, Special to Corona COVID-19 Virus

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- The Corona virus is capturing the world since the start of this year
- It is likely that it is just another symptom of our global climate change:
- https://www.scientificamerican.com/article/what-could-warming-mean-for-pathogens-like-coronavirus/
- “some experts believe **climate change**, along with other environmental disturbances, could help facilitate the **rise of more brand-new diseases**, like COVID-19.”
- Another interesting aspect:
- “Even if it does turn out to have some seasonal components in the future, that effect will likely be small this year, experts say.”

- It comes at the same time as the **catastrophical Australia Fires**, and **record temperatures on the south pole, melting of the south pole**:
- https://nymag.com/intelligencer/2020/02/what-coronavirus-teaches-us-about-climate-change.html
- “**Antarctica’s** Esperanza Peninsula reached 65 degrees Fahrenheit — the **warmest ever**...”
- “about a **hundred thousand years ago**, the **melting of the West Antarctic** ice sheet produced, all by itself, **six feet of sea-level rise** — and that it **took less than two degrees Celsius of warming** to melt it. We are **currently at about 1.1 degrees** of warming, but are heading almost inevitably for 2. “
- “A **quarter of the country’s (Australia) forests** have been **incinerated** in a single bushfire season, as have more than a billion of Australia’s animals.”

- This should be a reminder of how dangerous global climate change is for our human civilization.

Model for the Spread of COVID-19

- For the model I assume the **worst case**, that everything **continues as is**, with no effective countermeasures.
- It should be a **warning** about the dangers of **inaction**.

- Hopefully it will not come to this because we already have countermeasures, like cancelling meetings of people.
- I am not looking at the medical side, but purely at the mathematical statistical side.

- The spread of a virus is a good example of exponential growth in the beginning.
- When it reaches the carrying population size, it saturates and growth slows.
- Both phases are captured by the "**Logistic Function**" https://en.wikipedia.org/wiki/Logistic_function, section on "modeling population growth".
  Its formula is:

  $$P(t) = \frac{KP_0e^{rt}}{K + P_0\left(e^{rt} - 1\right)} = \frac{K}{1 + \left(\frac{K-P_0}{P_0}\right)e^{-rt}},$$

  Where `r=log(factorincrease)`, `factorincrease` is the factor of case increase from day to day; K: carrying capacity, population (83 Million or 83e6), P0 is the value of cases at t=0.
- In Germany we observe an increase of about 25% per day, or a factor of 1.25.
- We can estimate that factor of increase x from data from

https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Fallzahlen.html
(I made notes over time)
March 6: 639 cases in Germany
March 14: 3795 cases, 8 days in between
3795=x^8*639
3795/639=x^8
(2795/639)^(⅛)=x
1.25=x

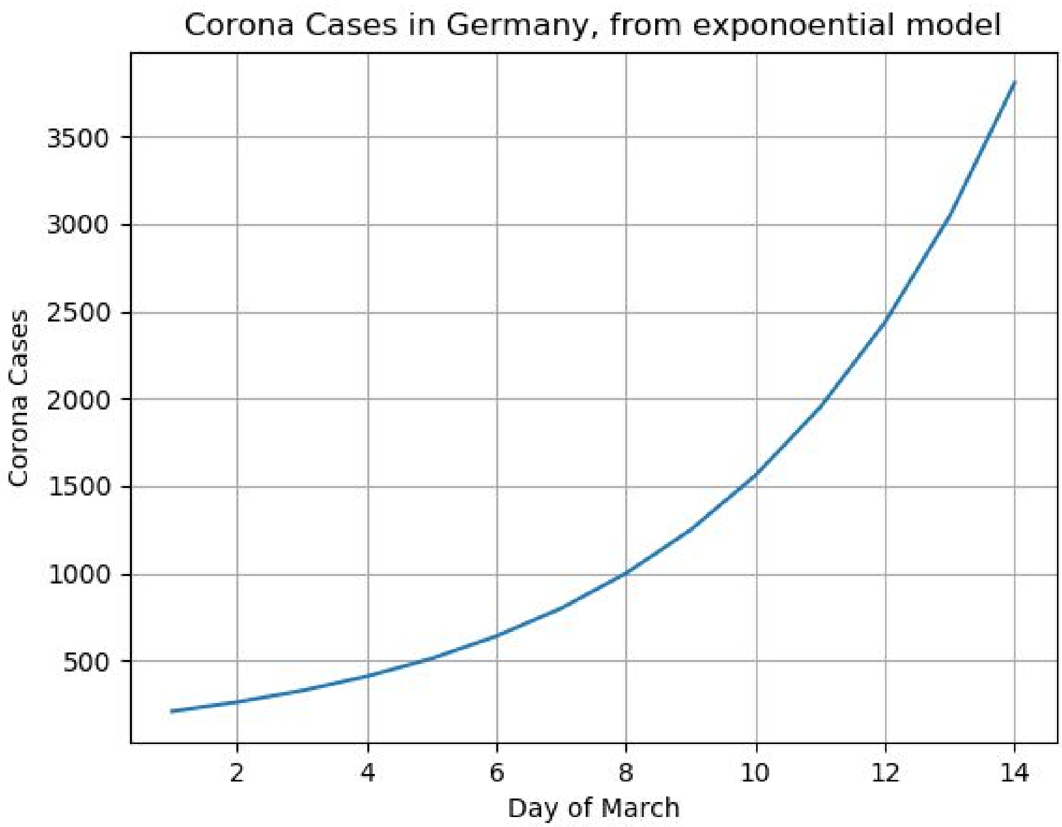
- We can observe a similar factor also in Australia or Brazil, which means it will probably **not pause in spring**.
- We observed 639 Corona cases on March 6,
639*(1.25^t) with t: days since March 6
- This formula also works for days before March 6, if we use negative numbers.
- I wrote a Python script with these numbers:

```
factorincrease=1.25  #increase factor day to day
valueondate=639  #value on a given day
dayofmonth=6 #the given day of the month of the
value
```

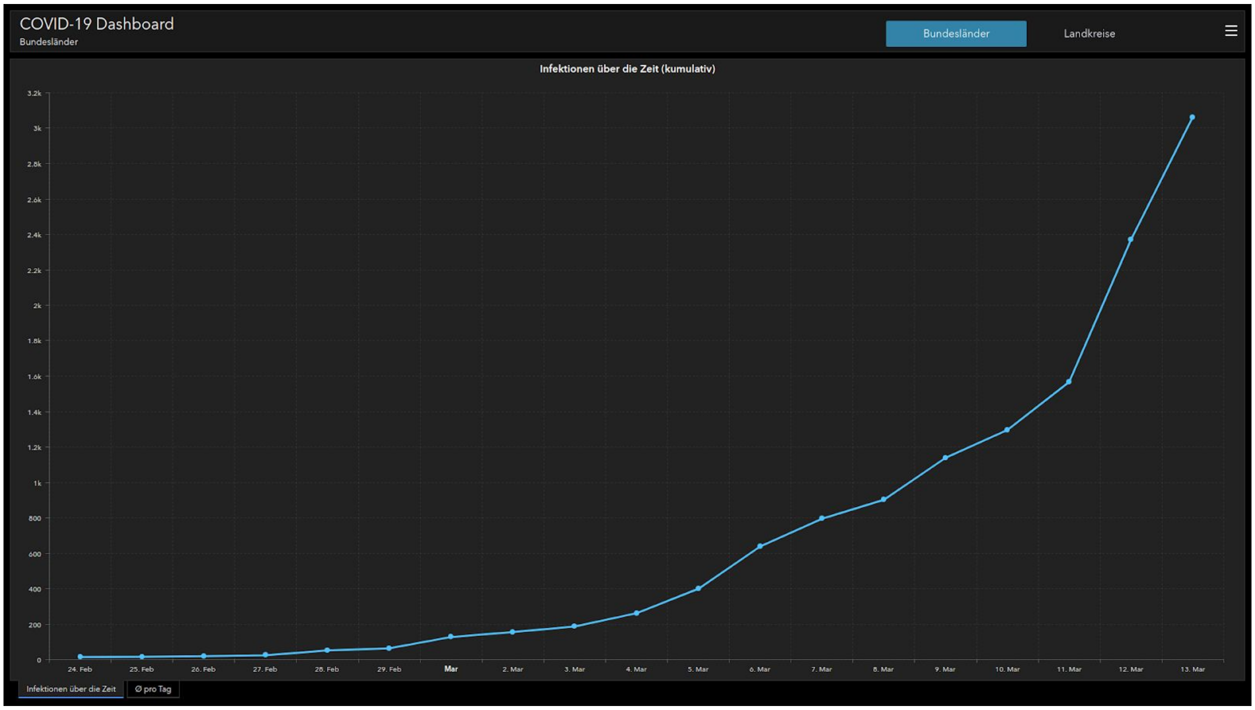
And plot the formula for the entire month of march, first half is verification, second half prediction.

```
t=np.arange(1,31) #prediction for this range of days of the
month. For the next month, use day numbers larger than 30.
plt.plot(t, logistic(K, valueondate, factorincrease,
t-dayofvalue) )
```

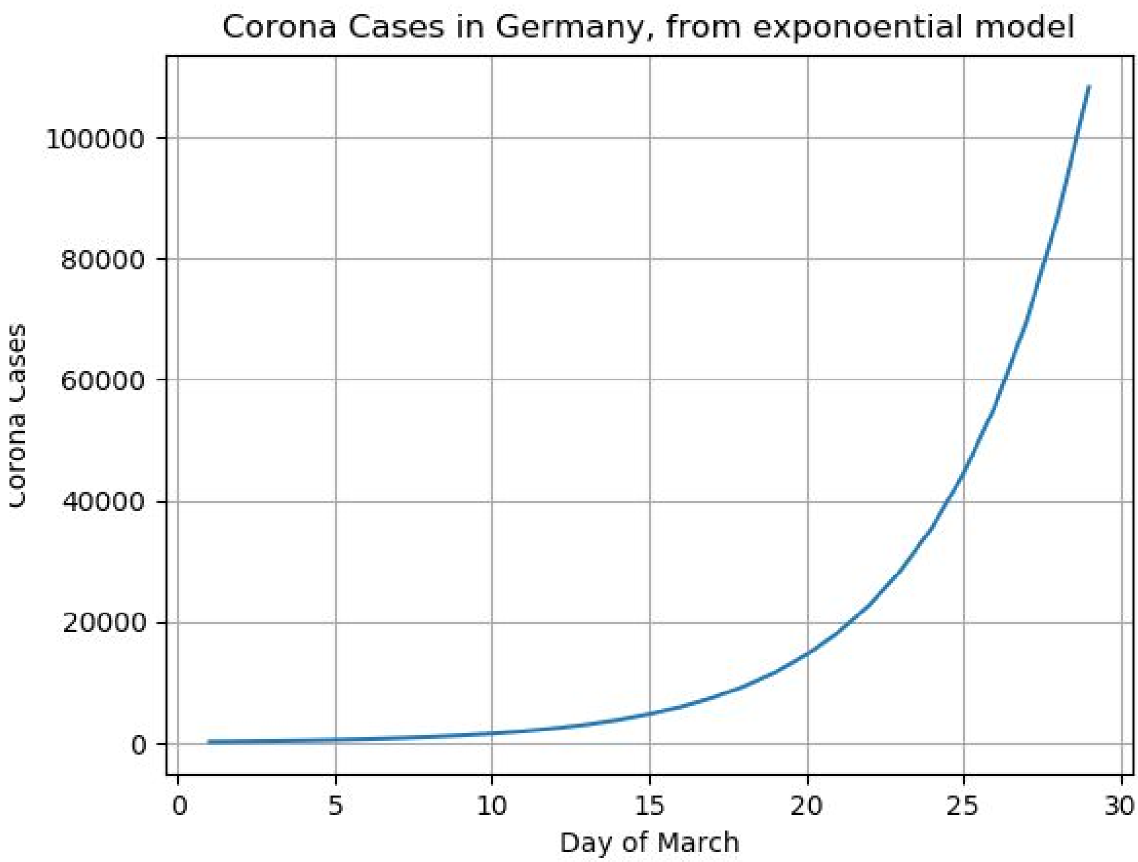
- We run the model with the command:
  `python3 coronacases.py`
- For the first half of the month we get:



We can now compare it to the data, from https://experience.arcgis.com/experience/478220a4c454480e823b17327b2bf1d4,
And find there is a good fit:



Now we can use this model for predicting the second half of March, and plotting the entire March:



Observe the typical exponential increase: For the end of March it already predicts over 100000 cases!

- We have about a 15% hospitalization rate, and 5% need critical care. (https://www.statnews.com/2020/03/10/simple-math-alarming-answers-covid-19/)
  Which means we need 15000 hospital beds and 5000 critical care beds then.
- Germany has about 500000 hospital beds, and 28000 critical care beds

(https://www.faz.net/aktuell/wirtschaft/corona-in-deutschland-bis-wann-reichen-die-krankenhaus-betten-16676537.html), so that might be sufficient.

But **April and May** is a different story.

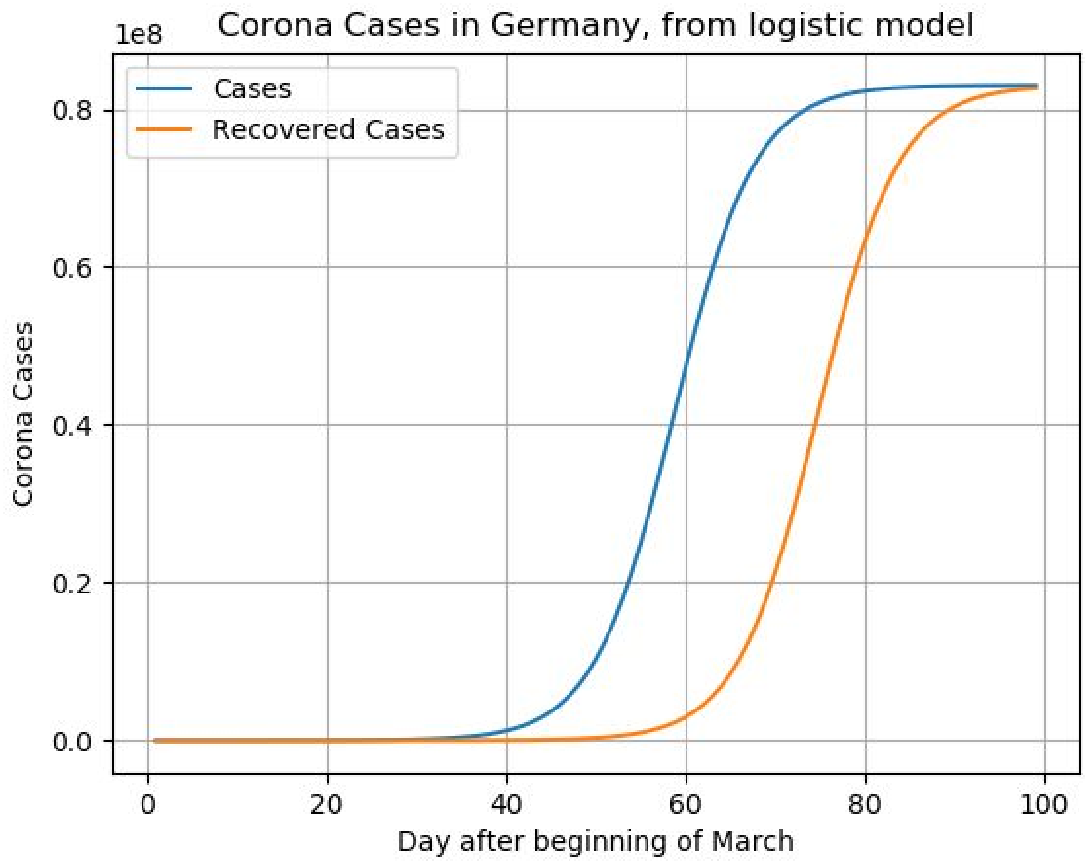
Recovery

- We can estimate the **time to recovery** by looking at the time lag from detecting cases to recovered cases
- For Germany, in https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6
  We can see that Germany has 46 recovered cases on March 15. On https://experience.arcgis.com/experience/478220a4c454480e823b17327b2bf1d4
  We see that on February 28, Germany had a similar number, 51, which is 16 days.
- Hence I assume on average it takes roughly **16 days from detection to recovery**.

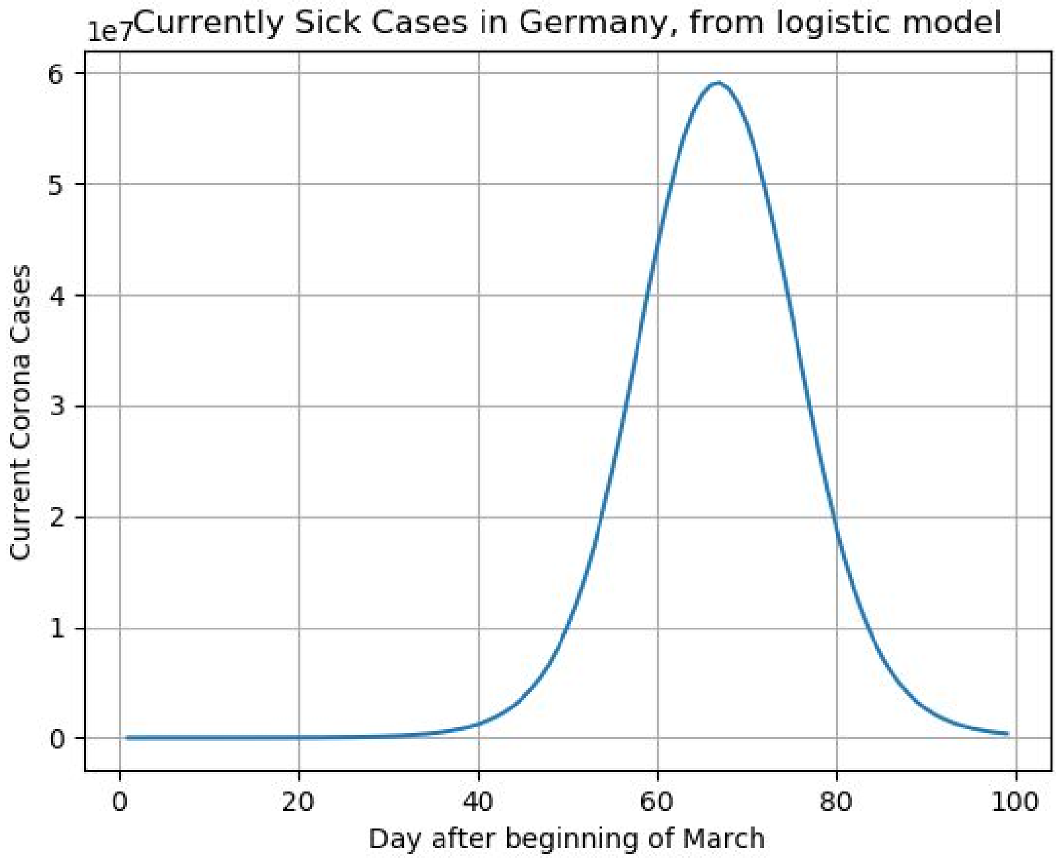
Currently sick or active cases

- We can now take these 16 days for recovery to compute the number of currently sick of active cases
- From the current cases we subtract the cases from 16 days ago.

- To see significant numbers of recovered cases, we need to look further ahead, say, 100 days from the beginning of March (early June). All still assuming there is no effective social distancing.
- The following shows a plot of total cases and of recovered cases:



The difference of the two shows then currently active or sick cases. We see: around day 70 the spread would slow down because of saturation.



Here we can see that we get a **peak** around day 66, which is **early May, at around 59 Million**.
If 15% of the active cases require hospitalization, the **peak is clearly too high to handle**, hence it is so **important to have countermeasures, like social distancing, to slow it down**.

Mortality rate

- According to figures from the Robert Koch Institute

https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Fallzahlen.html
we had 2 dead on March 9, 2369 cases and 5 deaths March 11, 8 deaths on March 14

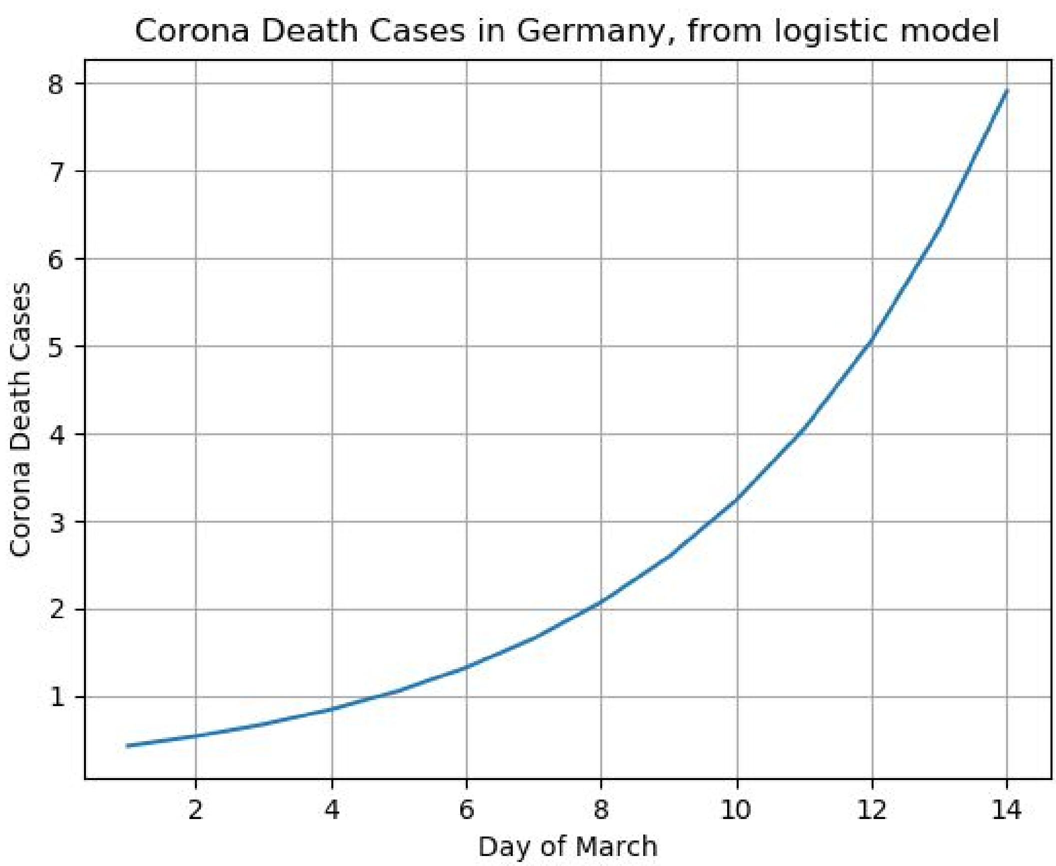
- These are **very few data points** yet, which makes my model more inaccurate.
- We can calculate a mortality factor for our model if we assume that it takes about 16 days from discovery to, instead of recovery, to potential death.
- The case numbers are now calculated back 16 days:
- 2369/(1.25^16)=66.7 cases. 5 of them have died,
- Hence a factor of 5/66.7=0.07. This is not the true mortality rate, it accounts for the undiscovered cases in our model!
- The factor to the true mortality rate is the under-reporting.
- In the beginning, this factor will produce more accurate numbers, later the true mortality rate will be more accurate.
- Hence I chose the true rate (assumed 2%) for the 100 day prediction, which underestimates the early rates.
- For the true mortality rate see:
- https://www.ecdc.europa.eu/en/novel-coronavirus-china/questions-answers
  Says it is 2%-3%
  See also:

https://time.com/5798168/coronavirus-mortality-rate/

- In comparison: the seasonal flu has 0.1%.

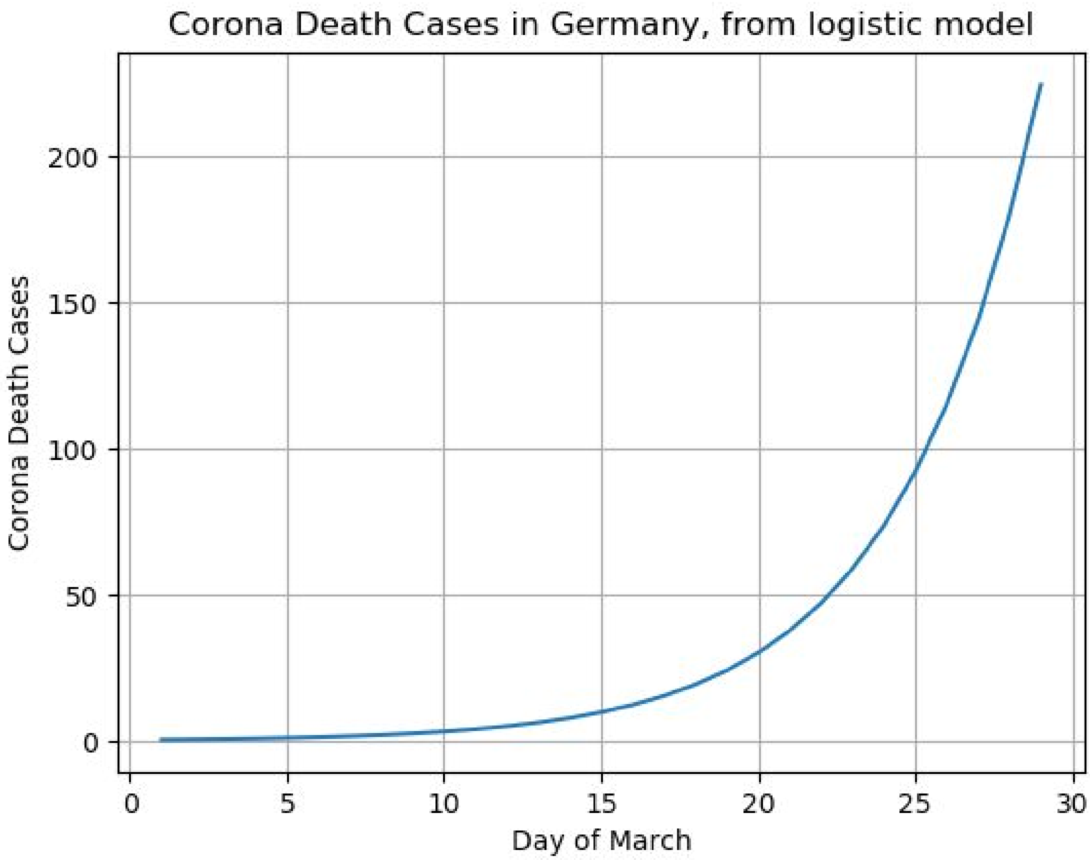
- Hence we now use our curve for the recovered cases, and multiply it with 0.07 to obtain a model for the death cases.

Plot of the first half of March as verification:



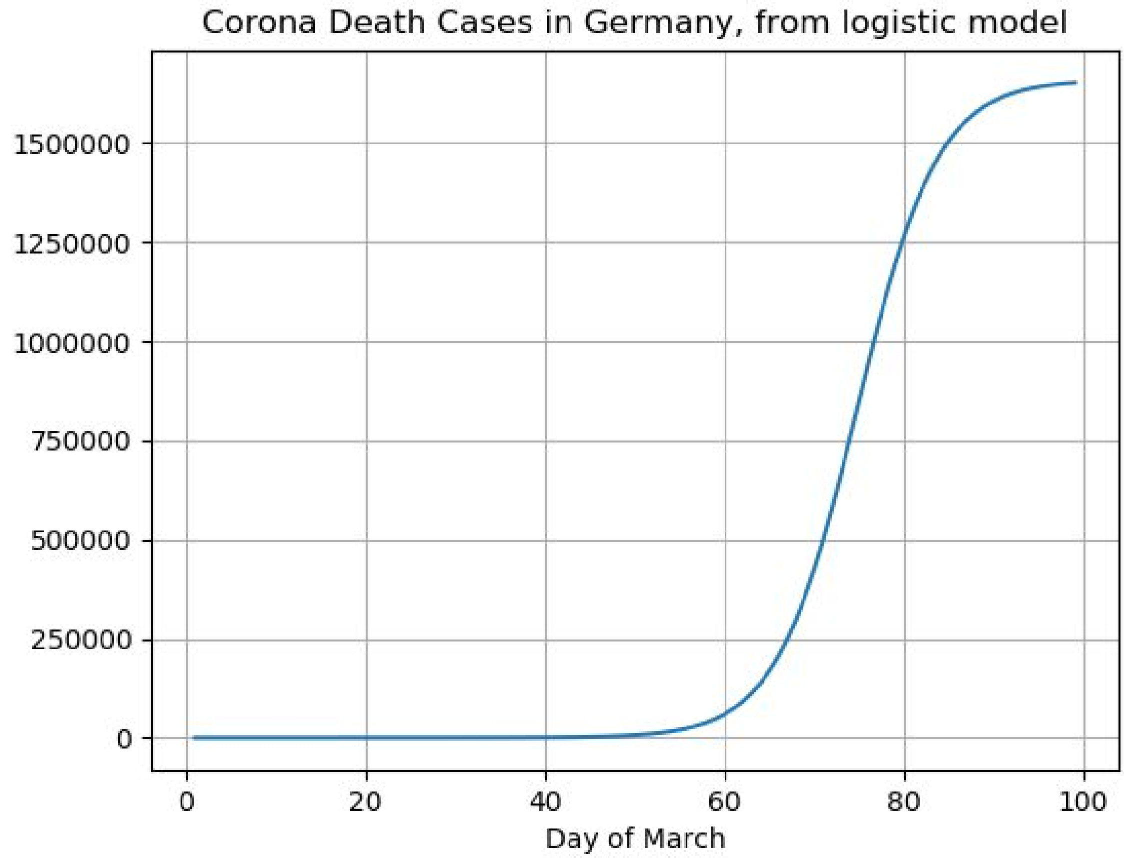
Compare: 2 dead on March 9, 5 dead on March 13, 8 deaths on March 14. It indeed fits our data points, but not very precisely.

Then we can use it for prediction, and plot the entire March:



We can see that we get about 215 dead at the end or March.

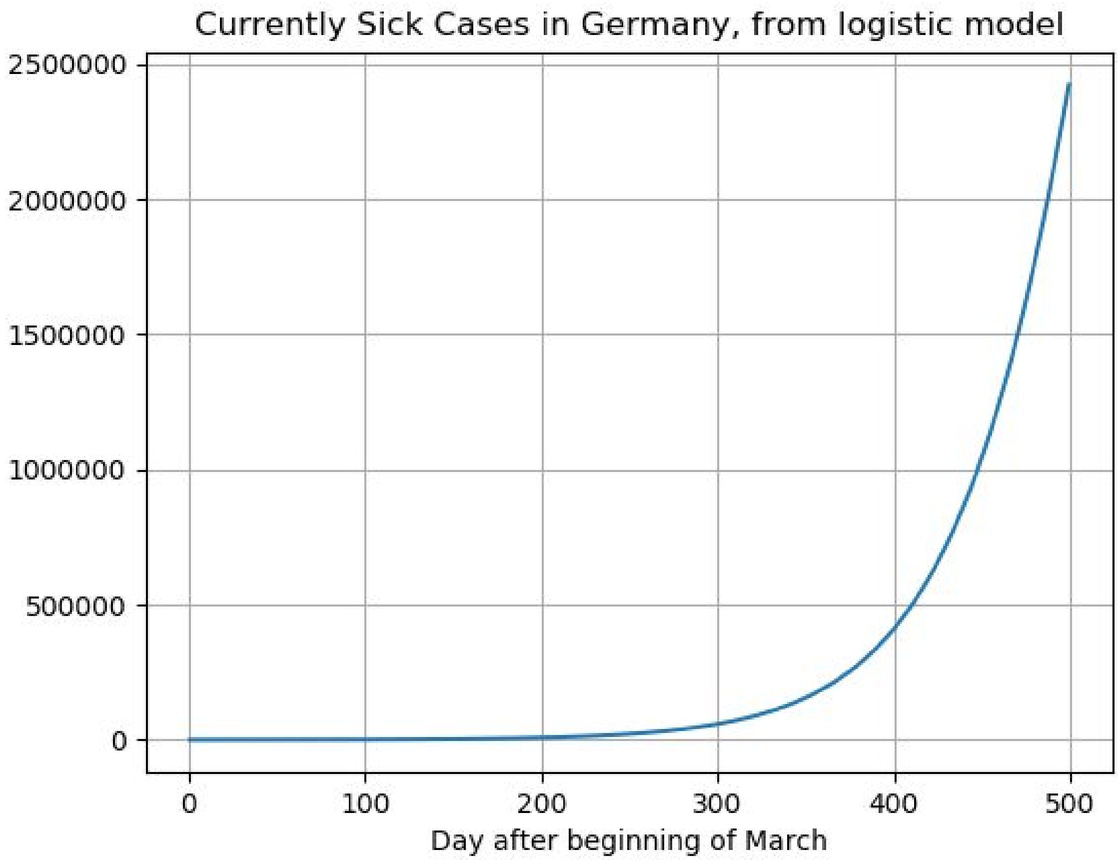
Now we can use our model to predict 100 days after the beginning of March (using the true mortality rate of 0.02):



We can see: after 100 days from the beginning of March, in early June, the model predicts accumulated about 1.6 Million deaths! This is much more than for a seasonal flu.

A possible Solution

If we could reduce the day to day factor of increase from 1.25 to 1.02 (2% increase per day), it would reduce the spread significantly. The plot of the currently sick cases would look like this:



Here we see that the peak comes **after a year**, and that is a time where we anticipate to have **vaccines**, to avoid this peak altogether!

Conclusions:

- It does not have to come to this catastrophe.
- It just shows the **danger of inaction**!
- **Similar to climate change**, where inaction will lead to catastrophes of much larger magnitudes!

- We need social distancing and other measures to slow it down, to **reduce the day to day factor of increase**.
- The virus will be with us until we have **vaccines and medication**.