Covid-19 Case Fitting Curves

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Based on data from Covid-19 cases from China, a universal fitting curve is presented to describe a given Covid-19 case data, and its growth rates, accumulated over a number of days. Only four parameters are required to be determined by a non-linear optimization. Under the special condition of reliable mass testing, this curve can indicate the flattening of a given case data after its inflection point has been reached. Analyses of weekly new cases will be forecast every Monday, including fitted case curves and growth rates.

CONTENTS

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I. MODEL

I.1. Model function

The hyperbolic tangent function,

$$Z_N(n) = a\tanh(bn - c) + d, \tag{1}$$

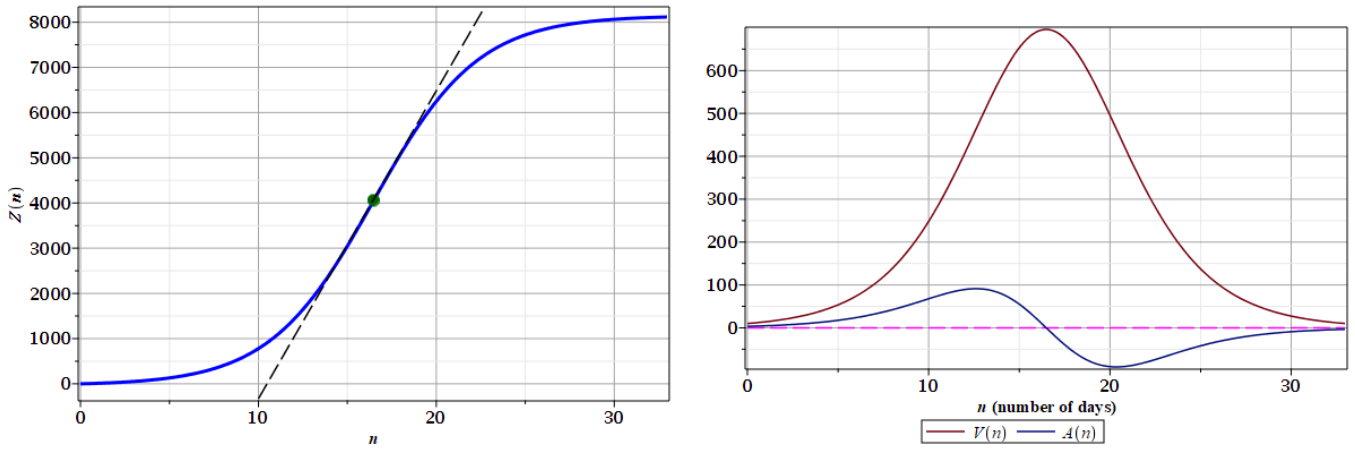
has two basic features of any Covid-19 case data over the number of days n: has flat endpoints and has one inflection point (at $n_i = c/b$). The final flattening indicates the stabilization of new infections. Parameter a, or $d = Z(n_i)$, gives the magnitude of the accumulated cases over N days. The amplitude is $2a$. The model function's steepness is tuned by the slope b of the straight line $bn - c$. Perhaps a q-deformed hyperbolic tangent could delivery a better response, using the deformation parameter to control its steepness as well.

Another important tools are the growth rates,

$$V(n) = \frac{dZ}{dn} = ab\,\mathrm{sech}(bn - c), \quad A(n) = \frac{dV}{dn} = -\frac{2b}{a}(Z(n) - d)V(n), \tag{2}$$

speed and acceleration, respectively. At the inflection point n_i, the speed is maximum ($V(n_i) = ab$) and the acceleration is null ($A(n_i) = 0$). Since the acceleration becomes negative after the inflection point, the speed diminishes and the stabilization is reached, the final flattening in the model function (1).

Figure 1a shows a typical case for the model function (1), where its magnitude is $a = 4086.9$ cases and its steepness is $0.170n - 2.807$ (dashed line). The green dot is the inflection point ($n_i = 16.48$). By the way, this model function represents the Covid-19 data case from New Zealand. Observe how the growth rates shown in Figure 1b are complete (as in no missing significant parts), indicating a real stabilization.



(a) Model function.

(b) Growth rates

FIG. 1: Model function $Z(n) = 4086.9\tanh(0.170n - 2.807) + 4057.2$, its inflection point (green dot at $n = 16.48$), its steepness (dashed line $0.170n - 2.807$) and its growth rates $V(n)$ and $A(n)$.

I.2. Strategy

The strategy is to learn possible universal features (conjectures) from analyses of Covid-19 case data of countries where the contamination process has been controlled. Subsequently, such conjectures will be applied to other cases in development.

Conjecture 1: monotonic convergence implies a possible stabilization (final flattening).

Conjecture 2: decreasing rms imply a possible stabilization.

Conjecture 3: complete growth rates imply a possible stabilization.

Conjecture 4: strong oscillations in the data require a multiple waves analysis.

Based on these conjectures, there are recommendations to extract information from the analyses given in the following sections. Important: the inflection point is a landmark in the middle of the road to stabilization.

How to read fitted curves:

1. Observe how close are the last fitted curve;
2. Observe the intensity and frequency of oscillations;
3. Observe how far is the final flattening;
4. Observe the root mean square (rms) deviations.

How to read growth rate curves:

1. Observe how intense is the speedy V;
2. Observe whether speedy V has reached its maximum or not;
3. Observe the acceleration's sign:
   (a) $A > 0$: speedy is trying to reach its maximum;
   (b) $A = 0$: speedy has reached its maximum (inflection point);
   (c) $A < 0$: speedy is decreasing and stability is foreseen.

Nonetheless, it is important to say that despite the (weak) evidences presented below, any prediction here is not to be taken for granted. Also, this is a simple exercise of reconversion, since I am not an expert neither in Statistics Science nor Immunology. See Refs. [1]–[6] for more accurate fitting schemes.

I.3. Parameters

Parameters $\{a, b, c, d\}$ appearing in the model function (1) were obtained inside Maple and Mathematica by a (local) non-linear fitting minimizing the root mean square (rms) deviations (both worksheet and notebook can be found here and here). All case data points are equally weighted. Case data from every country are available at Worldometer.

Root mean square (rms) deviations shown by inlets in figures belong to the fitted curve Z_N, where N is the number of days in a given case data. Lower the rms, better the fitting. Residual is the difference between reported and predicted cases, using the last day fitted curve.

II. CLOSED CASES

II.1. China

Figure 2 shows the case curves for the complete Covid-19 case data from China. The whole data seems to have a subseries described by the curve Z_{21}, obtained using the first 21 days, which indicates a (local) flattening of the cases over two weeks (around 53,700 cases). In spite of this curve Z_{21} being a false lead in searching for the case flattening, since we know the whole history, it has all features of a typical (complete) case curve. In fact, a close analysis in this subseries shows an inflection point around $n = 14$. Also, while the nearest case curves $Z_{N\leq 21}$ approach Z_{21} in an oscillatory way, all case curves $Z_{N\geq 23}$ approach Z_{74} monotonically. Curve Z_{74}, obtained using 74 days, is the global case curve, which indicates a flattening around 81,000 cases. The (global) curve Z_{74} shown in Figure 2 is the (lower) limit for all curves $Z_{N\geq 22}$ and has its inflection point around $n = 21$. Since all curves $Z_{N\geq 29}$ converge monotonically and rapidly to Z_{74}, then we have a 10 days prediction for the (global) flattening occurring around day 50. **Conjecture 1: monotonic convergence implies a possible stabilization (final flattening).**

We have learned that the case curves Z_N obtained after the inflection point converge monotonically, in an increasing speed, to the global case curve. Of course, mass testing is presumed. Inset in Figure 2 shows the root mean square (rms) deviations of each case curve $Z_{N\geq 24}$, confirming the monotonic convergence.

Some questions. What did happen at day 22? Was it an increase in the total tests? Or is this jump in the number of cases from day 21 to the day 22 (see the solid green circles in Figure 2) a typical feature of the global case curve around its inflection point (where the rate of change is maximum)?

Figure 3 shows the case data accumulated over weeks and the last five fitted curves together with their root mean square (rms) deviations shown in the inset. Note that these last fitted curves are very close each other and the rms deviations are decreasing, indicating a stabilization. **Conjecture 2: decreasing rms imply a possible stabilization.**

Growth rates are shown in Figures 4 (daily) and 5 (weekly). They are complete curves, indicating a global stabilization starting around day 50 (week eight). The inflection point is around day 18 or around week three. **Conjecture 3: complete growth rates imply a possible stabilization.**

II.2. South Korea

South Korea has a case data with three waves, as shown in Figure 6. The first wave Z_a ends at day 30, the second wave Z_b ends at day 80 and the last wave Z_c starts at day 83. These multiple waves represent new cases of infection, a very important lesson to be learned. Till day 80, stabilization seemed granted. Now a third wave is underway, growing slowly. Due these multiple waves, the global curve Z_{114} does not represent some portions of the observed data very well, mainly in the beginning. However, the root mean square (rms) deviations from the fitted curves Z_N (using the whole data for the N last days) is decreasing, as shown in the inset in Figure 6. **Conjecture 4: strong oscillations in the data require a multiple waves analysis.**

Figure 7 shows the case data accumulated over weeks and the last five fitted curves together with their root mean square (rms) deviations (shown in the inset). Note that these last fitted curves are very close each other (even not considering multiple waves) and the rms deviations are decreasing, indicating a stabilization.

Daily growth rates are shown in Figures 8 (whole set) and 9 (first wave). Note that the growth rates are not complete in Figure 8, some important portions are missing in the left side. The reason is that they were derived from the global curve Z_{114}, which fails to represent the observed data in the beginning. However, these same growth rates indicates an inflection point around day 15 and a stabilization around day 80, all true if not the third wave. It is quite instructive to have a look at the growth rates in Figure 9, derived from the first wave (the most strong). Here the growth rates are complete. All this means that we must use all four conjectures established so far all together.

II.3. New Zealand

New Zealand have reached a global flattening, givem by the global curve Z_{89}, as we can see in Figure 10. Figure 11 shows the case data accumulated over weeks and the last five fitted curves together with their root mean square (rms) deviations shown in the inset. Note that these last fitted curves are very close each other and the rms deviations are decreasing, indicating a stabilization given by the global curve Z_{13}. Growth rates are shown in Figures 12 (daily) and 13 (weekly). They are complete curves, indicating a global stabilization starting around day 70 (week 11). The inflection point is around day 33 (week 5.5).

III. ALMOST CLOSED CASES

Almost Closed Cases show some Covid-19 case data close to their global flattening or at least beyond their inflection points. New waves of new infections are not ruled out. In fact, many case data shown here present oscillations which require a multi-wave analysis.

III.1. Spain

Daily and weekly accumulated case data from Spain are shown in Figures 14 and 15, respectively. The insets show the root mean square (rms) deviations. Increasings in the rms in the last days are due to strong oscillations in the data. Growth rates (2) from the last fitted curves are shown in Figures 16 (daily, from Z_{107}) and 17 (weekly, from Z_{16}). They are complete curves and indicate an inflection point around day 46 (week 7.5). There are strong evidences of a stabilization.

III.2. Italy

Daily and weekly accumulated case data from Italy are shown in Figures 18 and 19, respectively. The insets show the root mean square (rms) deviations. Increasings in the rms in the last days are due to small oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 20 (daily, from Z_{114}) and 21 (weekly, from Z_{17}). They are complete curves and indicate the inflection point around day 48 (week 7.7). There are strong evidences of a stabilization.

III.3. France

Daily and weekly accumulated case data from France are shown in Figures 22 and 23, respectively. The insets show the root mean square (rms) deviations. Increasings in the rms in the last days are due to strong oscillations (or small jumps) in the data. Growth rates (2) from the last day fitted curves are shown in Figures 24 (daily, from Z_{107}) and 25 (weekly, from Z_{16}). They are complete curves and indicate the inflection point around day 45 (week 7.3). There are evidences of a stabilization.

III.4. Germany

Daily and weekly accumulated case data from Germany are shown in Figures 26 and 27, respectively. The insets show the root mean square (rms) deviations. Increasings in the rms in the last days are due to strong oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 28 (daily, from Z_{107}) and 29 (weekly, from Z_{16}). They are complete curves and indicate the inflection point around day 42 (week 6.9). There are evidences of a stabilization.

III.5. Japan

Daily and weekly accumulated case data from Germany are shown in Figures 30 and 31, respectively. The insets show the root mean square (rms) deviations. Increasings in the rms in the last days are due to medium oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 32 (daily, from Z_{114}) and 33 (weekly, from Z_{17}). They are complete curves and indicate the inflection point around day 61 (week 9.5). There are evidences of a stabilization.

IV. POST-INFLECTION POINTS

All countries listed bellow have common features indicating that their case data are near their inflection points. Since their five last fitted curves are ordered, with the last day (blue) curve at the top, and quite distant from each other at the (false) flattening region, it shows (probably) that the inflection point was not reached yet, but it is close. There are growing oscillations in the residuals, which superpose a modulation in the case data, requiring a multiple waves analysis.

IV.1. USA

Daily and weekly accumulated case data from USA are shown in Figures 34 and 35, respectively. The insets show the root mean square (rms) deviations. Note that all these last fitted curves are orderly approaching each other. Increasings in the rms in the last days are due to strong oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 36 (daily, from Z_{114}) and 37 (weekly, from Z_{17}). They are incomplete curves and indicate the inflection point around day 73 (week 11.4).

IV.2. Russia

Daily and weekly accumulated case data from Russia are shown in Figures 38 and 39, respectively. The insets show the root mean square (rms) deviations. Note that all these last fitted curves are orderly approaching each other. Increasings in the rms in the last days are due to small oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 40

(daily, from Z_{100}) and 41 (weekly, from Z_{15}). They are incomplete curves and indicate the inflection point around day 76 (week 11.8).

IV.3. UK

Daily and weekly accumulated case data from UK are shown in Figures 42 and 43, respectively. The insets show the root mean square (rms) deviations. Note that all these last fitted curves are orderly approaching each other. Increasings in the rms in the last days are due to medium oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 44 (daily, from Z_{107}) and 45 (weekly, from Z_{16}). They are incomplete curves and indicate the inflection point around day 63 (week 9.8).

IV.4. Peru

Daily and weekly accumulated case data from Peru are shown in Figures 46 and 47, respectively. The insets show the root mean square (rms) deviations. There are small oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 48 (daily) and 49 (weekly). They are incomplete curves and indicate the inflection point around day 86 (week 13).

IV.5. Turkey

Daily and weekly accumulated case data from Turkey are shown in Figures 50 and 51, respectively. The insets show the root mean square (rms) deviations. There are strong oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 52 (daily) and 53 (weekly). They are incomplete curves and indicate the inflection point around day 35 (week 5.9).

IV.6. Mexico

Daily and weekly accumulated case data from Mexico are shown in Figures 54 and 55, respectively. Their root mean square (rms) deviations are shown in the insets. So far there are no significant oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 56 (daily) and 57 (weekly). They are incomplete curves with a recent inflection point around day 97 (week 14.8).

IV.7. Saudi Arabia

Daily and weekly accumulated case data from Saudi Arabia are shown in Figures 58 and 59, respectively. Their root mean square (rms) deviations are shown in the insets. There are small oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 60 (daily) and 61 (weekly). They are incomplete curves with a recent inflection point around day 75 (week 11.6).

IV.8. Canada

Daily and weekly accumulated case data from Canada are shown in Figures 62 and 63, respectively. The insets show the root mean square (rms) deviations. Note that all these last fitted curves are orderly approaching each other. Increasings in the rms are due to medium oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 64 (daily) and 65 (weekly). They are almost complete curves and indicate the inflection point around day 73 (week 11.3).

V. PRE-INFLECTION POINTS

Countries bellow seem to have not reached their inflection points yet, as we can see in their growth rates. Mild to strong oscillations in the data spread out the last five fitted curves, making them not ordered and, consequently, diminish our confidence

in the growth rates. Growth rates from weekly accumulated cases are less sensitive to oscillations.

V.1. Brazil

Figure 66 shows the case curves for the last five days for the Brazilian case data (Dados Transparentes). Figure 67 shows the case data accumulated over weeks and the last three fitted curves. The insets show the increasing root mean square (rms) deviations. There are frequent small oscillations in the data. Growth rates (2) from the last day fitted curves are shown in Figures 68 (daily) and 69 (weekly). They are incomplete curves and indicate that the inflection point will be reached soon.

V.2. India

Daily and weekly accumulated case data from India are shown in Figures 70 and 71, respectively. The insets show the increasing root mean square (rms) deviations. Note that all these last fitted curves are still distant each other. Growth rates (2) from the last day fitted curves are shown in Figures 72 (daily) and 73 (weekly). They are incomplete curves and indicate that the inflection point will be reached soon.

V.3. Chile

Daily and weekly accumulated case data from Chile are shown in Figures 74 and 75, respectively. The insets show the increasing root mean square (rms) deviations. Growth rates (2) from the last day fitted curves are shown in Figures 76 (daily) and 77 (weekly). They are incomplete curves and indicate that the inflection point will be reached soon.

VI. FIGURES

VI.1. China

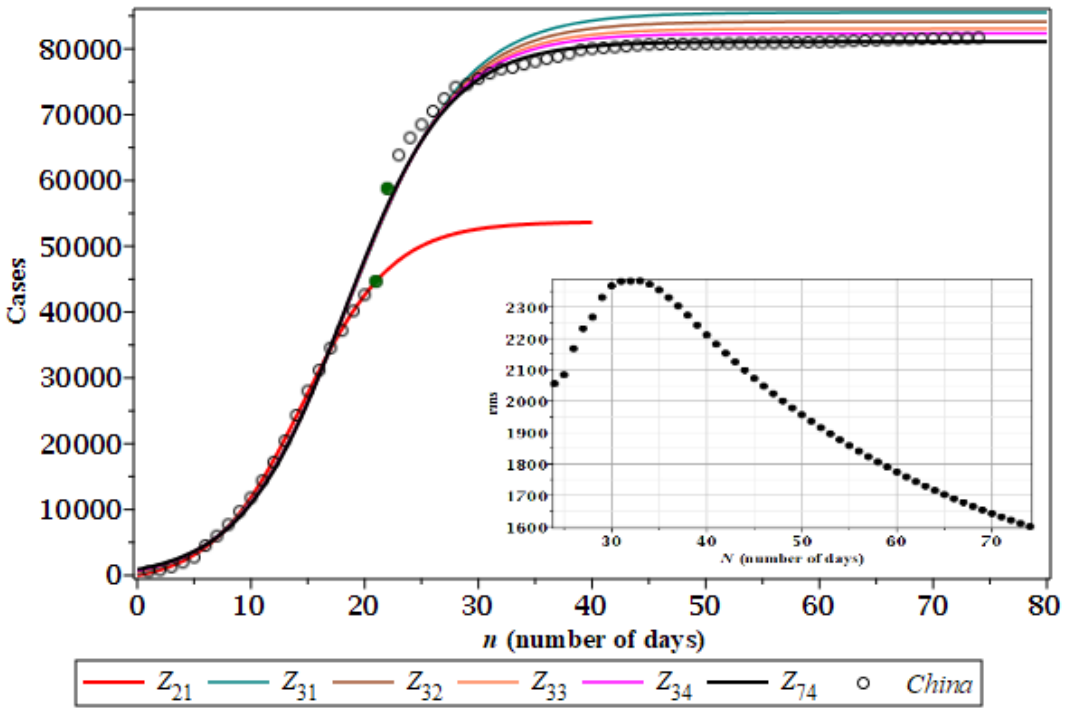


FIG. 2: Daily Covid-19 case curves and rms for the data from China. $Z_{74} = 40823 \tanh(0.110n - 2.005) + 40264$.

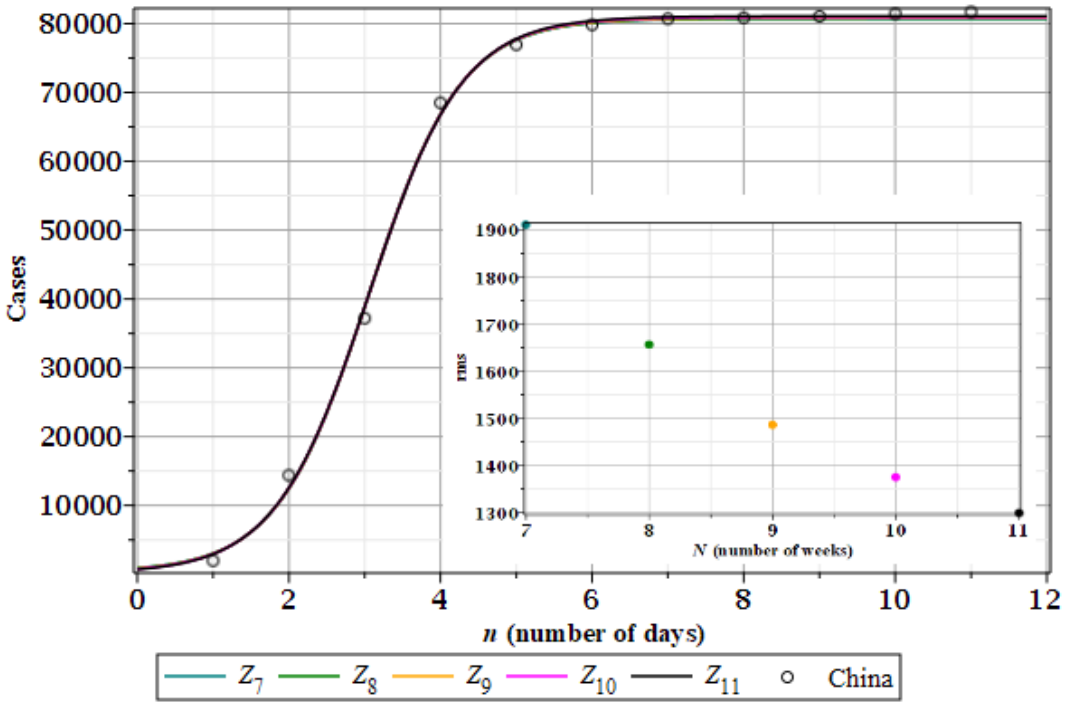


FIG. 3: Weekly Covid-19 case curves and rms for the data from China. $Z_{11} = 40466 \tanh(0.811n - 2.479) + 40611$.

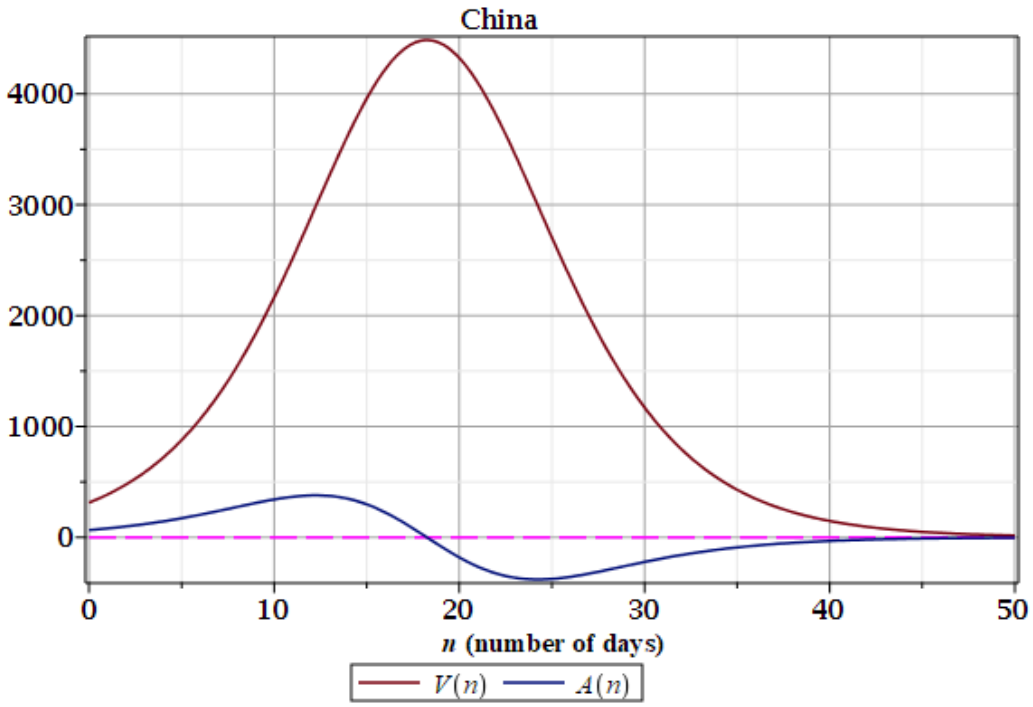


FIG. 4: Daily growth rates from $Z_{74} = 40823 \tanh(0.110n - 2.005) + 40264$. Complete curves. Inflection point: $n \approx 18$.

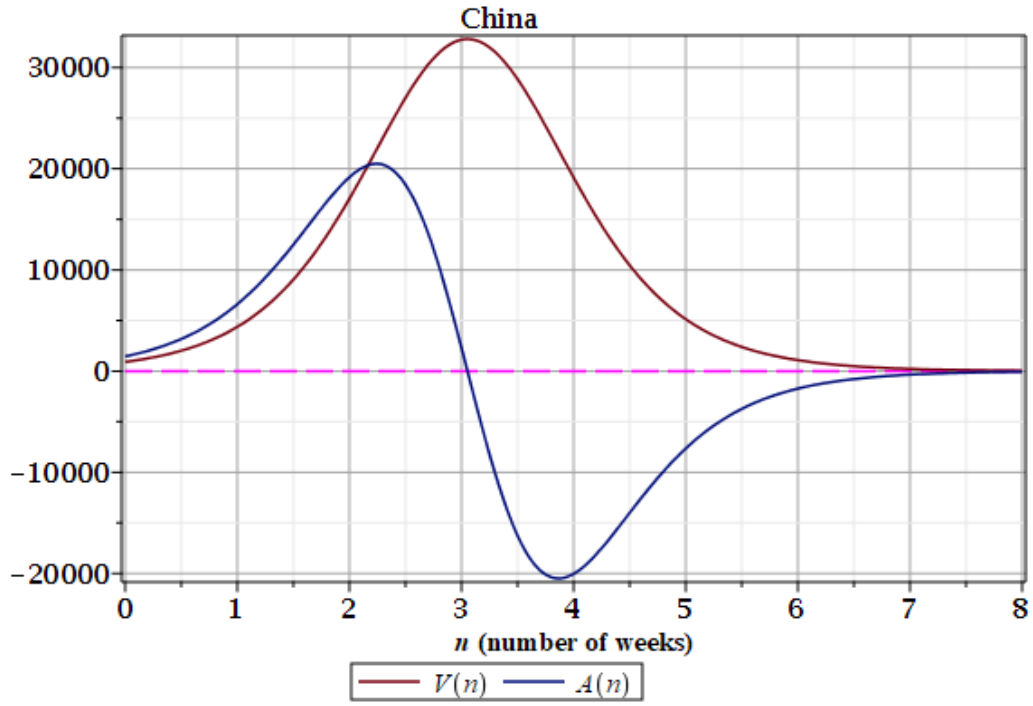


FIG. 5: Weekly growth rates from $Z_{11} = 40466 \tanh(0.811n - 2.479) + 40611$. Complete curves. Inflection point: $n \approx 3$.

VI.2. South Korea

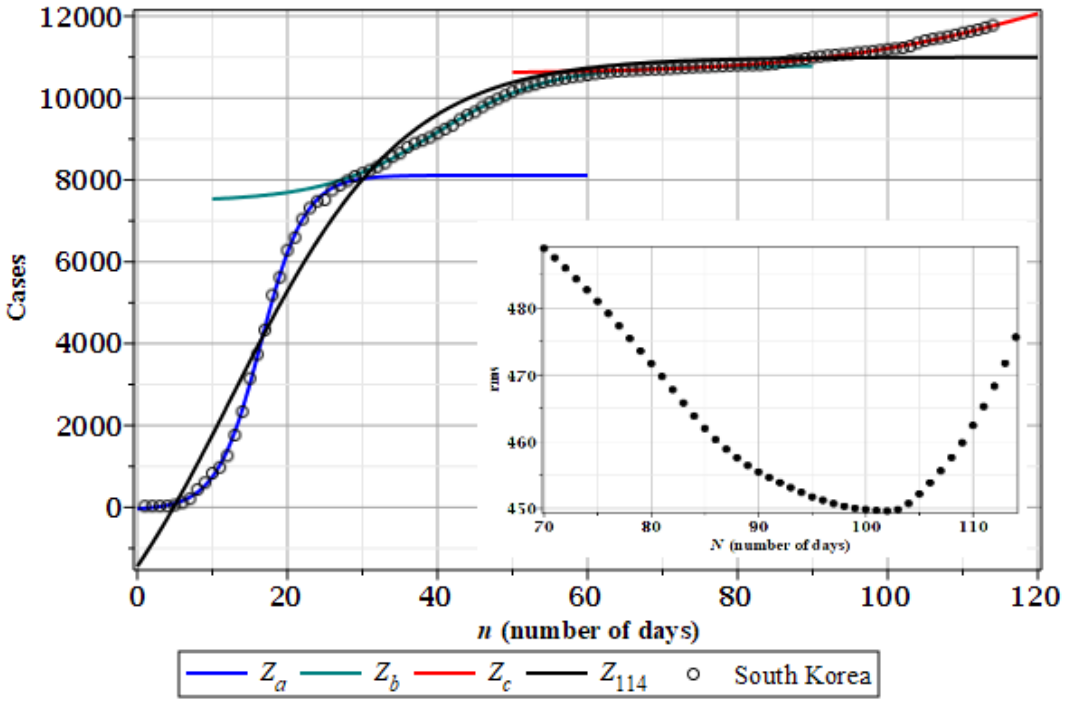


FIG. 6: Daily Covid-19 case curves and rms for the data from South Korea. First wave: $Z_a = 4087\tanh(0.170n - 2.807) + 4024$. Last wave: $Z_c = 1740\tanh(0.030n - 3.815) + 12333$.

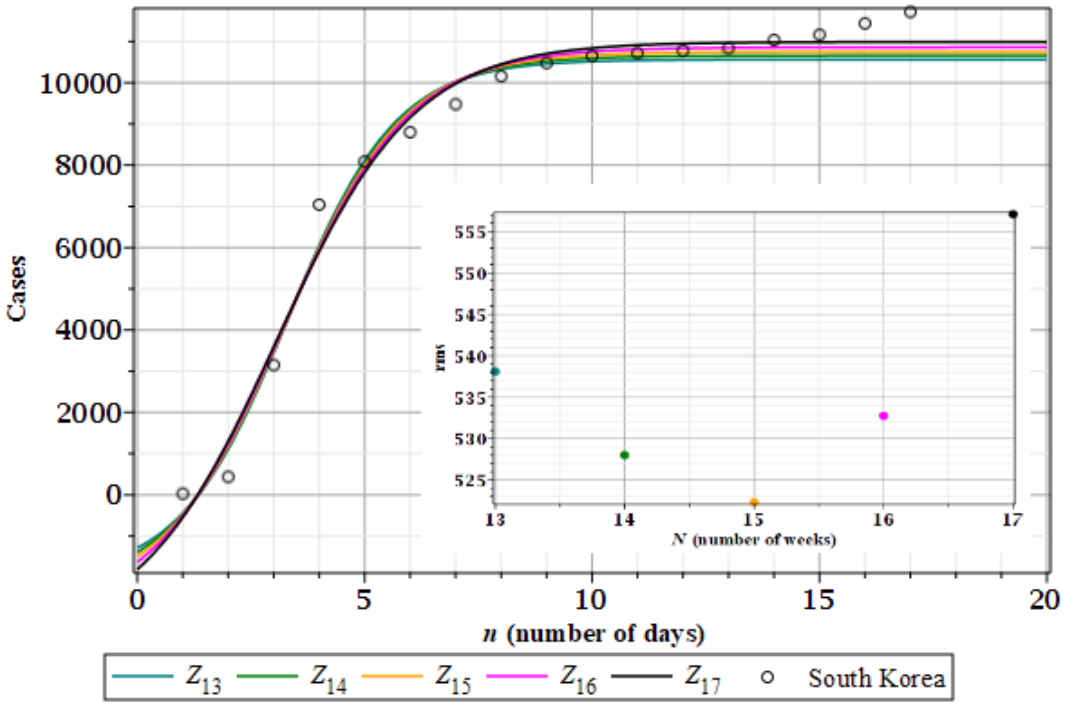


FIG. 7: Weekly Covid-19 case curves and rms for the data from South Korea. $Z_{17} = 7255\tanh(0.329z - 1.006) + 3736$.

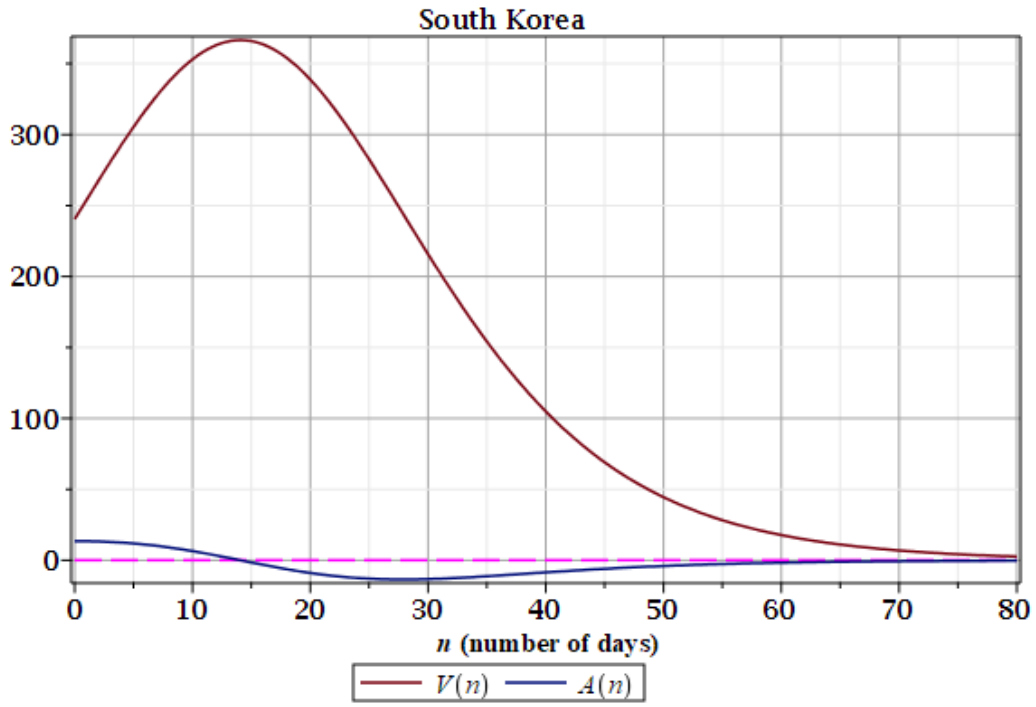


FIG. 8: Daily growth rates from $Z_{114} = 8290\tanh(0.043n - 0.550) + 2705$. Semi-complete curves. Inflection point: $n \approx 12.6$.

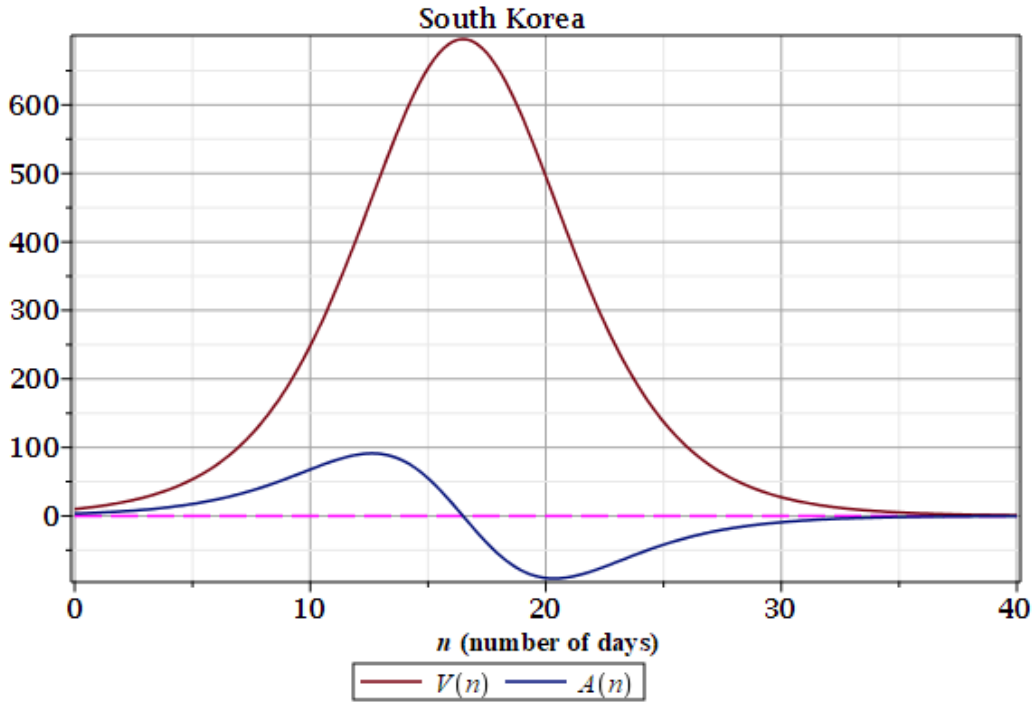


FIG. 9: Daily growth rates from the first wave $Z_a = 4087\tanh(0.170n - 2.807) + 4024$. Complete curves. Inflection point: $n \approx 16.5$.

VI.3. New Zealand

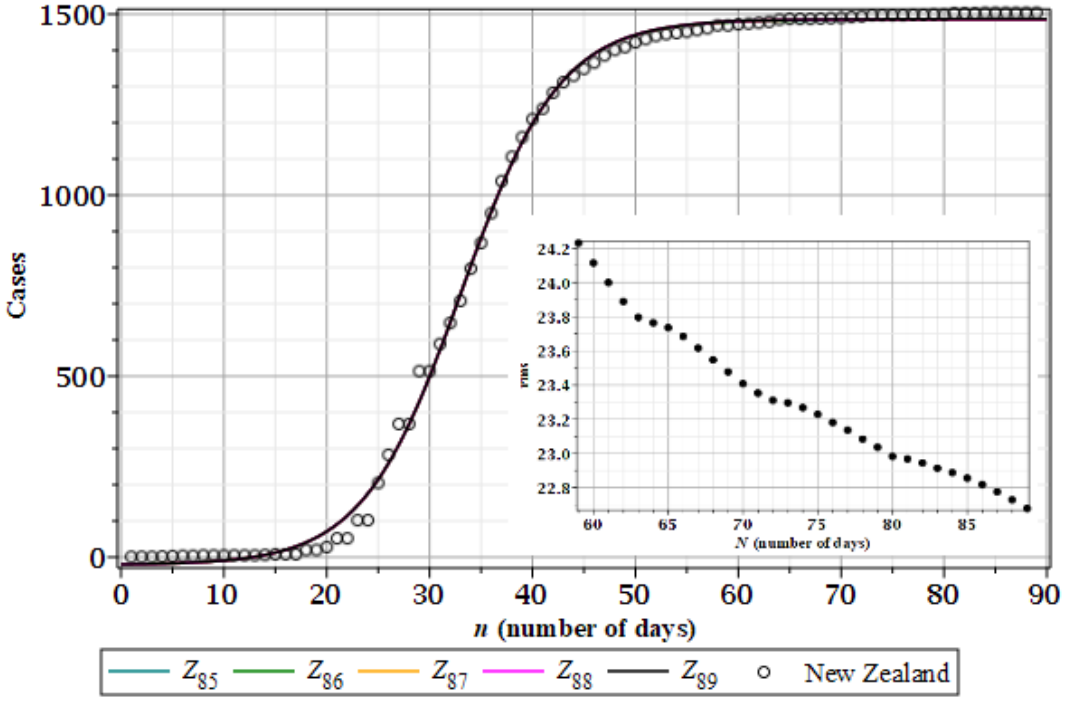


FIG. 10: Daily Covid-19 case curves amd rms for the data from New Zealand. $Z_{89} = 754\tanh(0.104n - 3.445) + 732$.

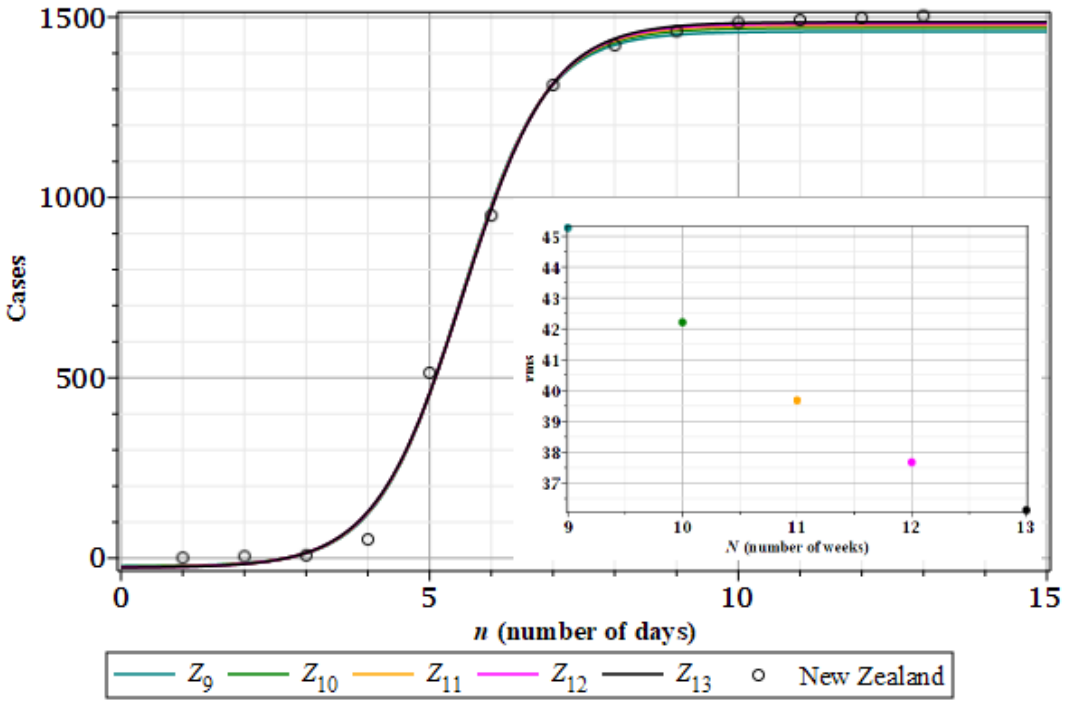


FIG. 11: Weekly Covid-19 case curves amd rms for the data from New Zealand. $Z_{13} = 756\tanh(0.705n - 3.901) + 730$.

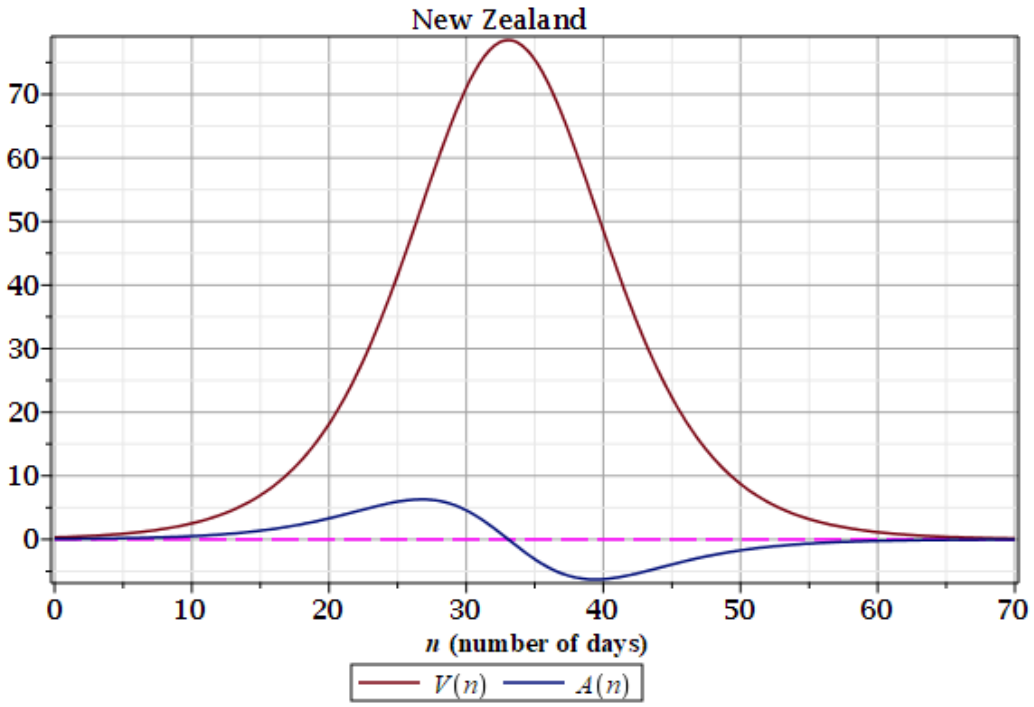


FIG. 12: Daily growth rates from $Z_{89} = 754 \tanh(0.104n - 3.445) + 732$. Complete curves. Inflection point: $n \approx 33$.

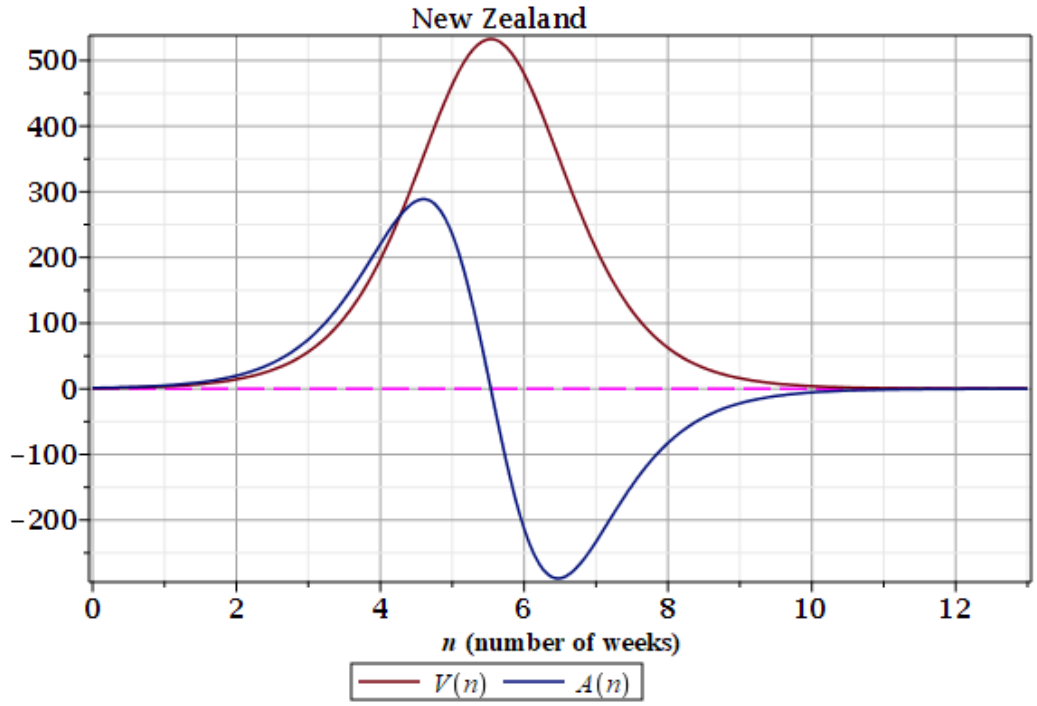


FIG. 13: Daily growth rates from $Z_{13} = 756 \tanh(0.705n - 3.901) + 730$. Complete curves. Inflection point: $n \approx 5.5$.

VI.4. Spain

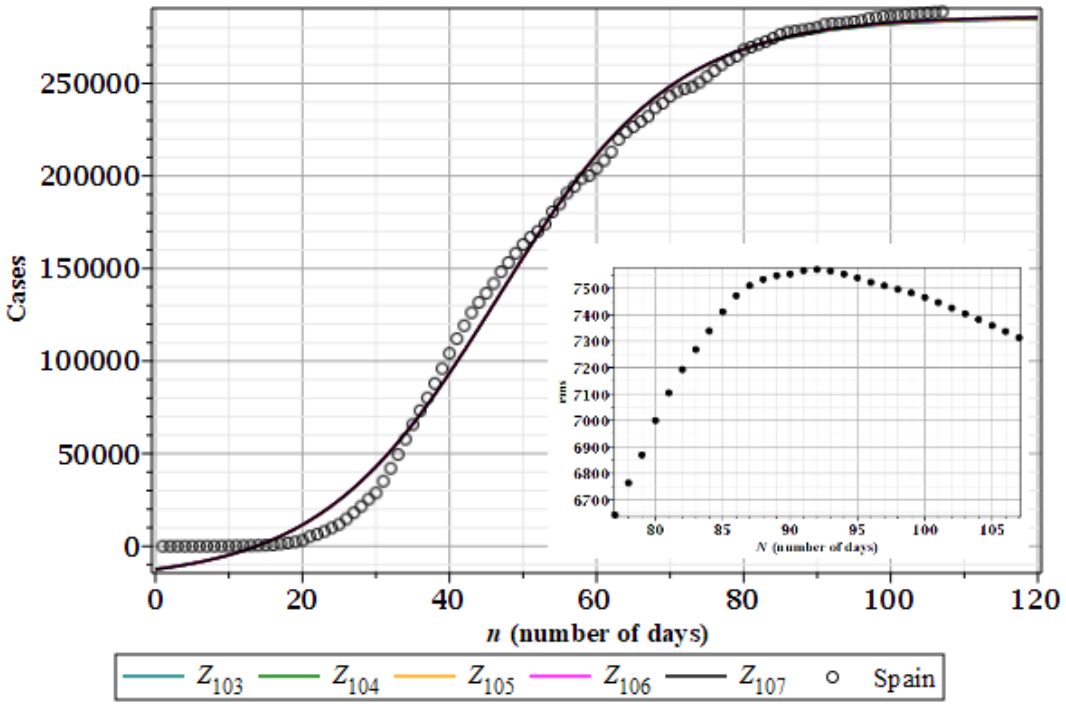


FIG. 14: Daily Covid-19 case curves and rms for the data from Spain. $Z_{107}(n) = 152610 \tanh(0.042n - 1.931) + 133805$.

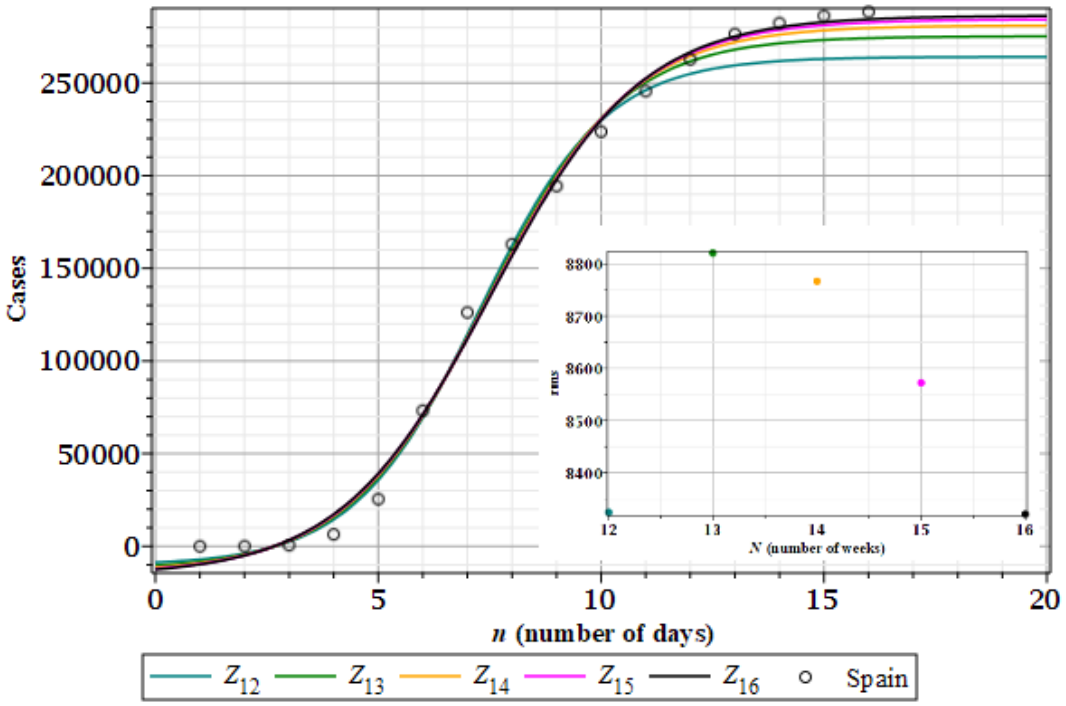


FIG. 15: Weekly Covid-19 case curves for the data from Spain. $Z_{16}(n) = 151121 \tanh(0.297n - 2.236) + 135245$.

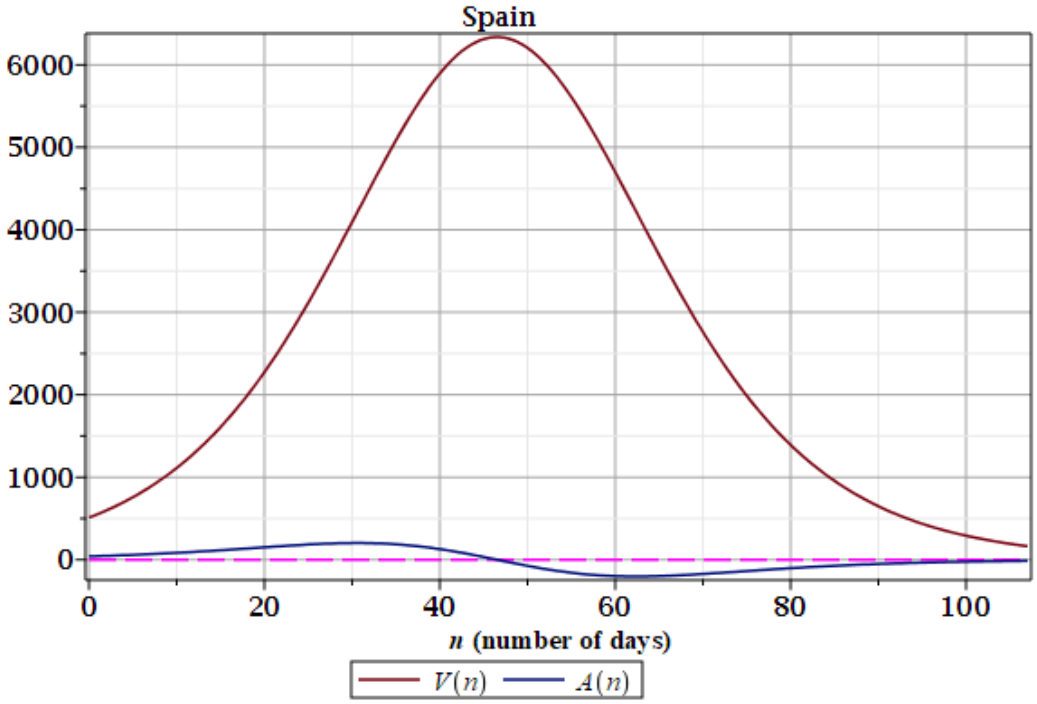


FIG. 16: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{107}. Complete curves. Inflection point: $n \approx 46$.

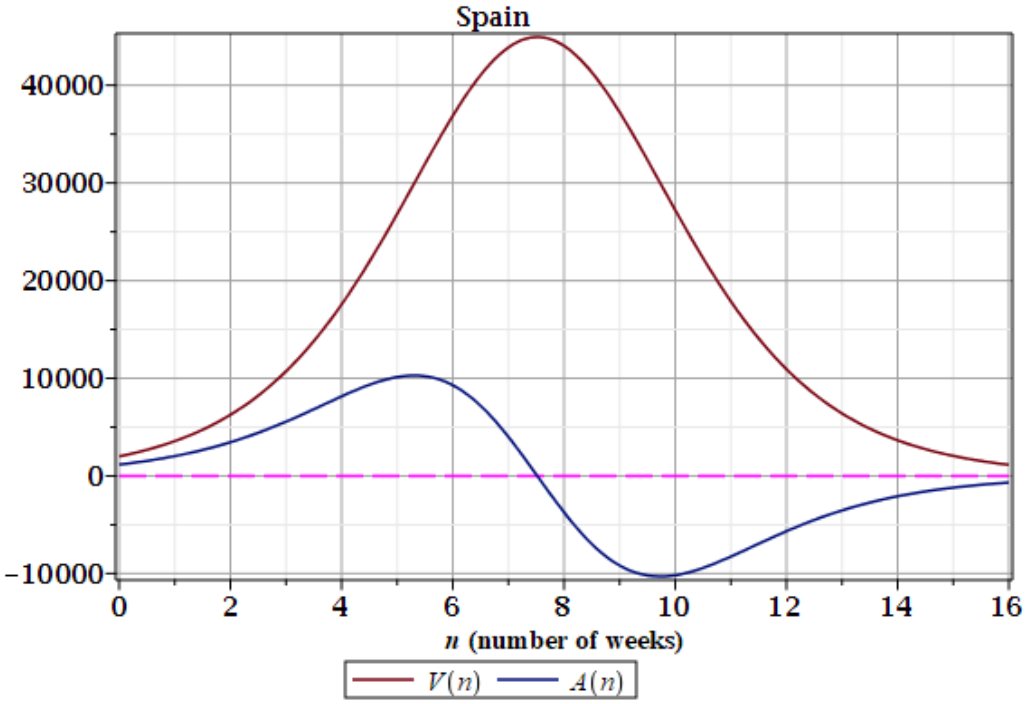


FIG. 17: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{16}. Complete curves. Inflection point: $n \approx 7.5$.

VI.5. Italy

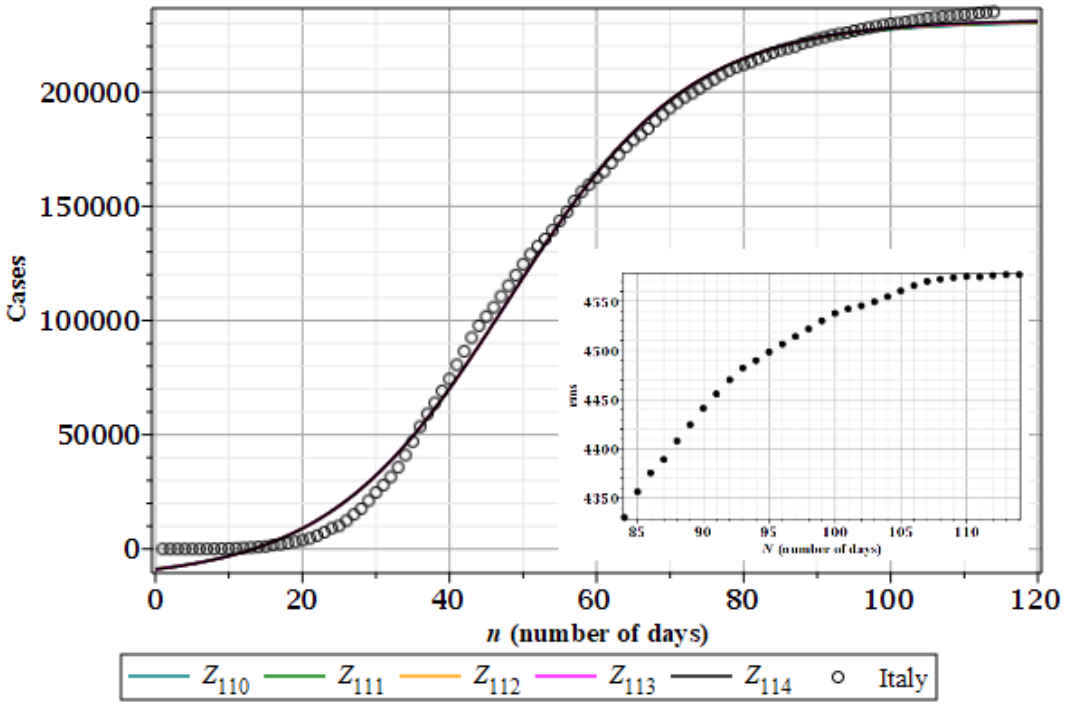


FIG. 18: Daily Covid-19 case curves and rms for the data from Italy. $Z_{114}(n) = 122724 \tanh(0.041n - 1.951) + 108963$.

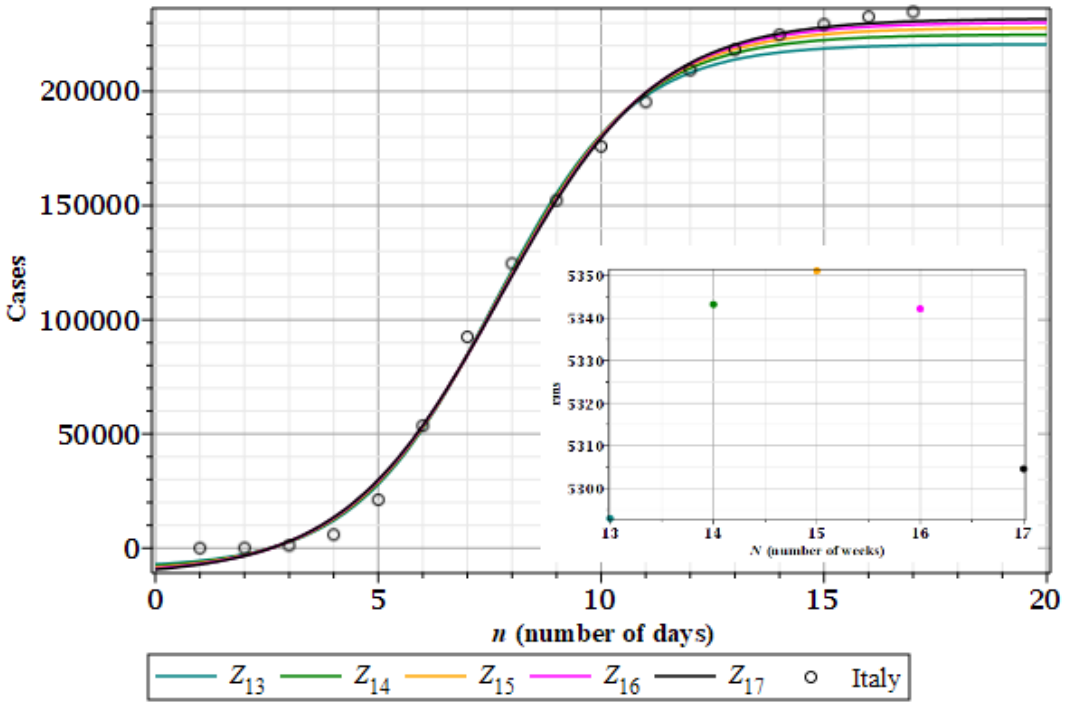


FIG. 19: Weekly Covid-19 case curves and rms for the data from Italy. $Z_{17}(n) = 122017 \tanh(0.287n - 2.217) + 109841$.

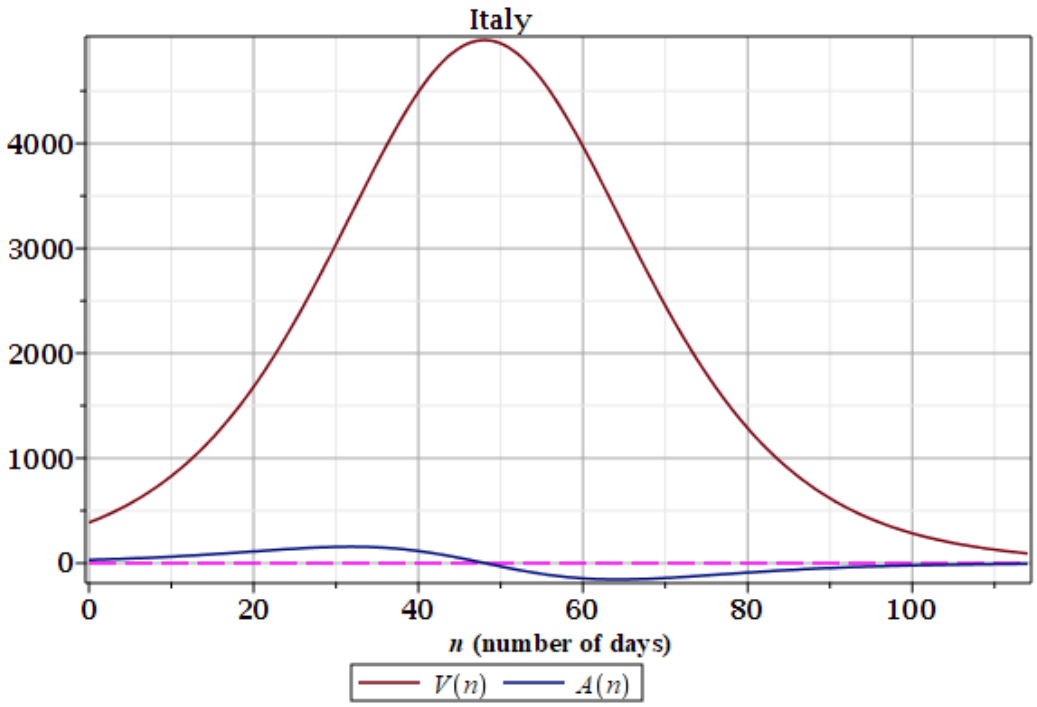


FIG. 20: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{114}. Complete curves. Inflection point: $n \approx 48$.

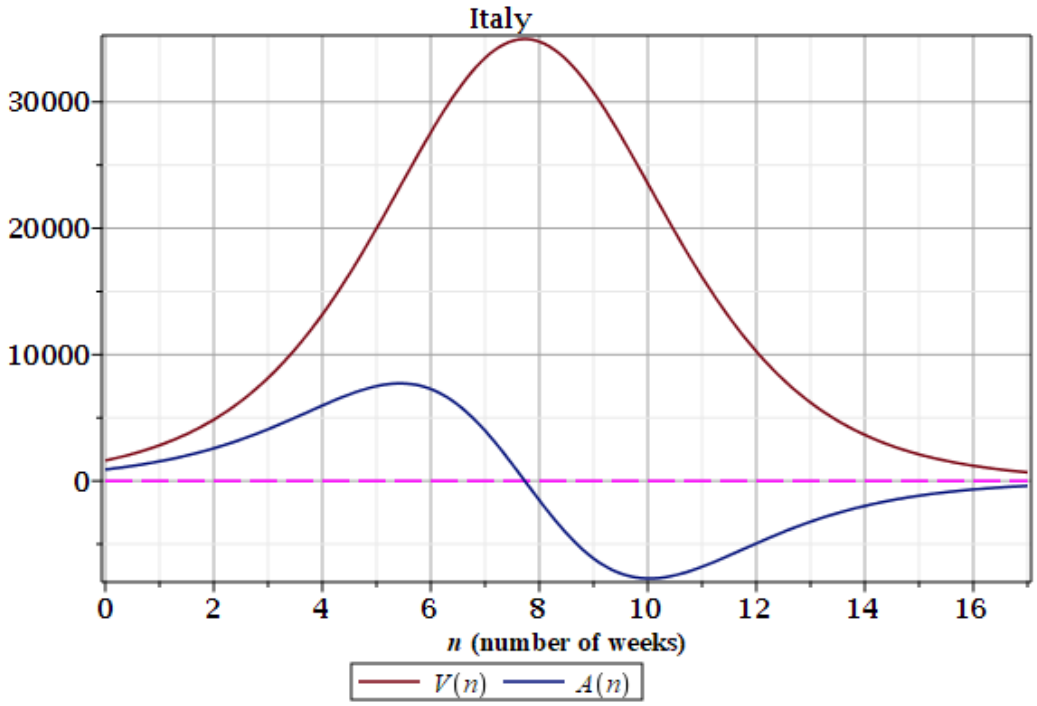


FIG. 21: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{17}. Complete curves. Inflection point: $n \approx 7.7$.

VI.6. France

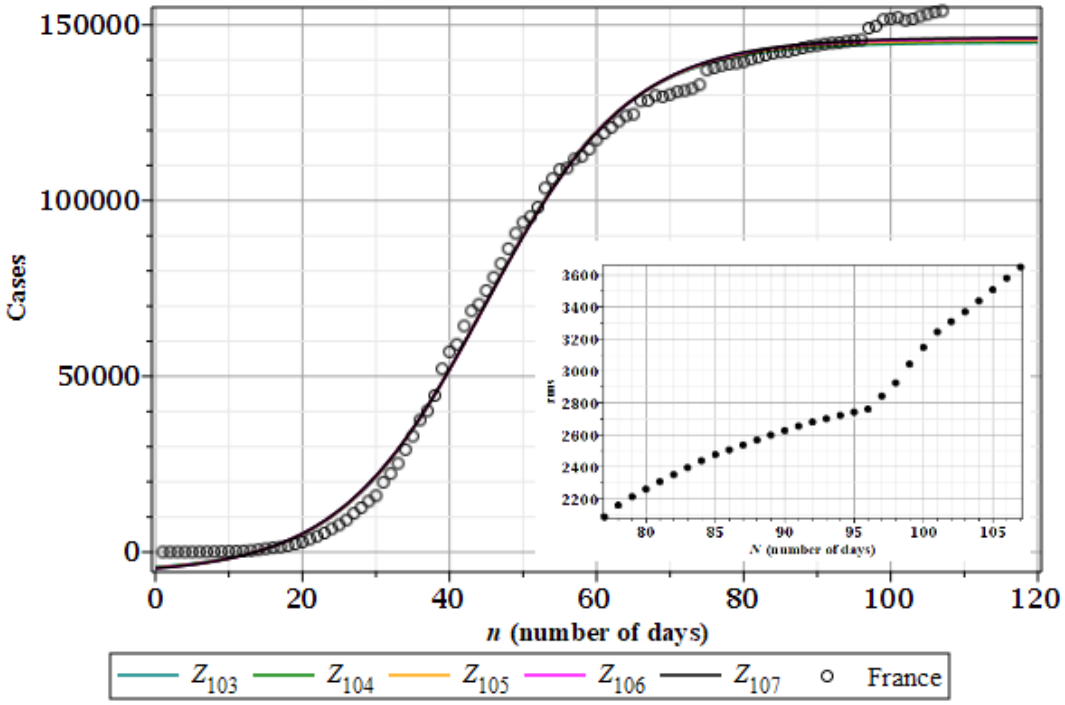


FIG. 22: Covid-19 case curves and rms for the data from France. $Z_{107}(n) = 76359\tanh(0.050n - 2.259) + 70066$.

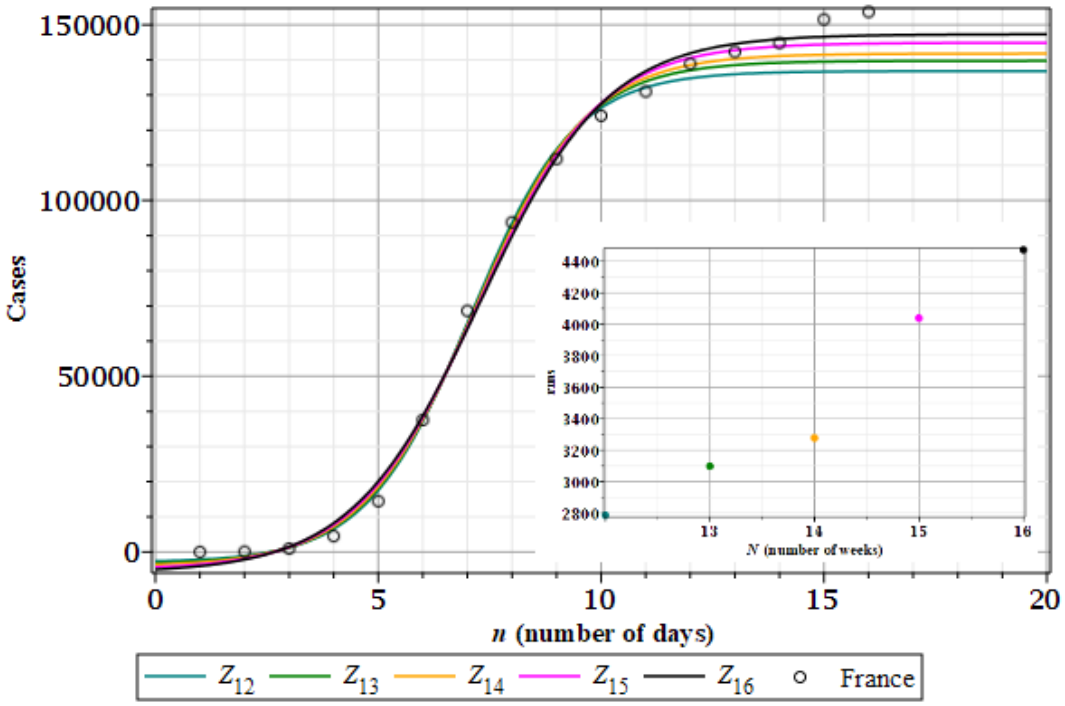


FIG. 23: Weekly Covid-19 case curves and rms for the data from France. $Z_{16}(n) = 76579\tanh(0.350n - 2.543) + 70692$.

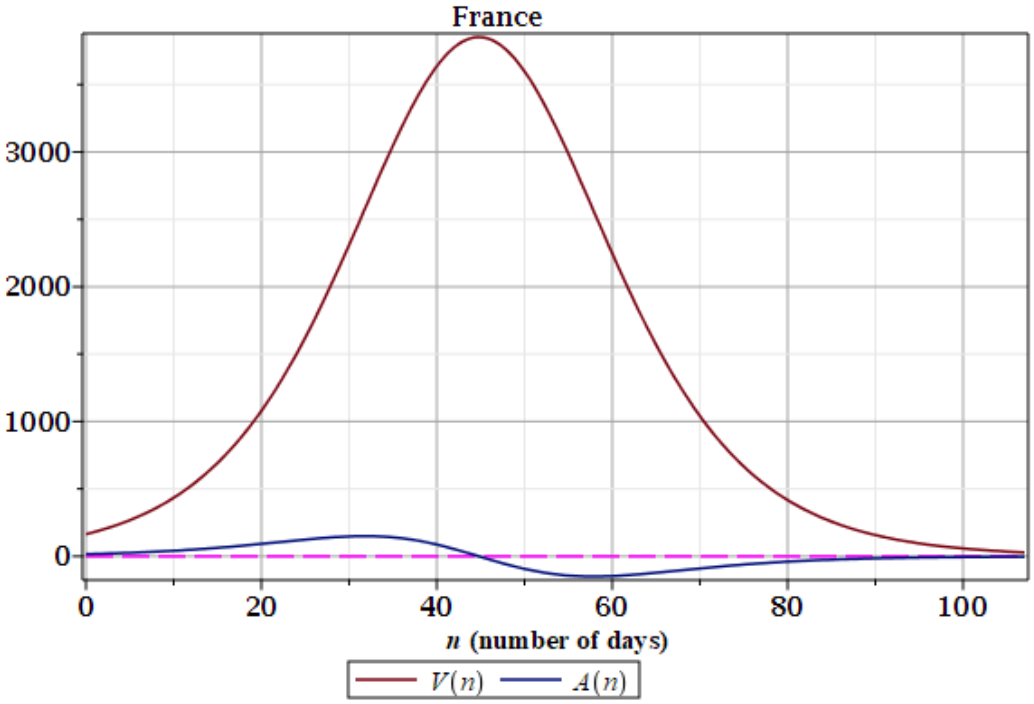


FIG. 24: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{107}. Complete curves. Inflection point: $n \approx 45$.

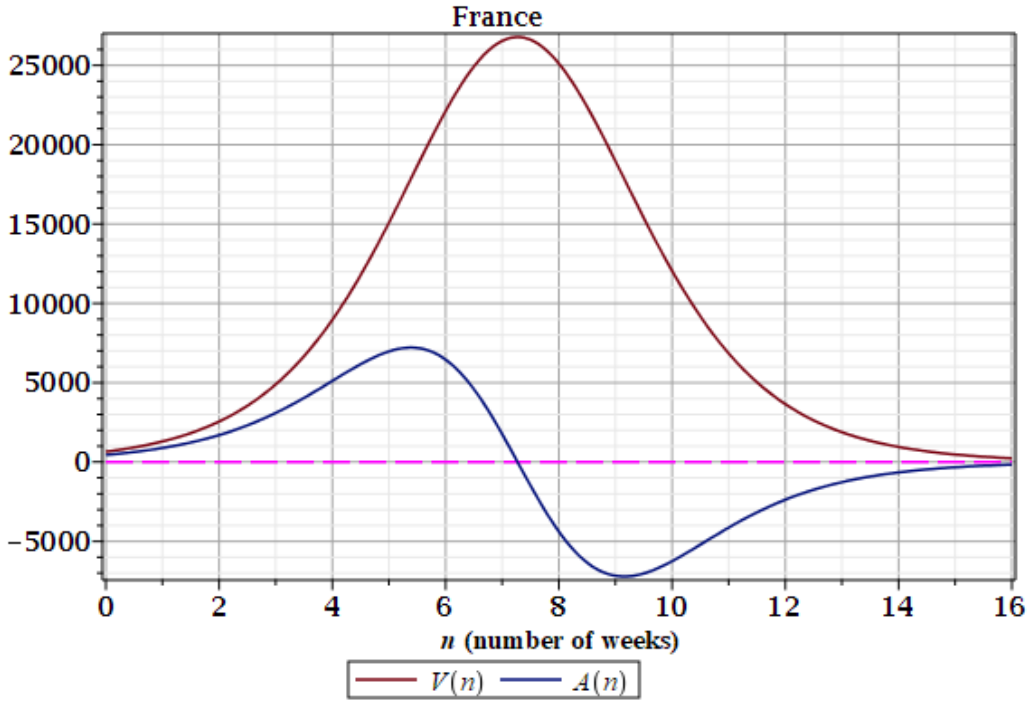


FIG. 25: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{16}. Complete curves. Inflection point: $n \approx 7.3$.

VI.7. Germany

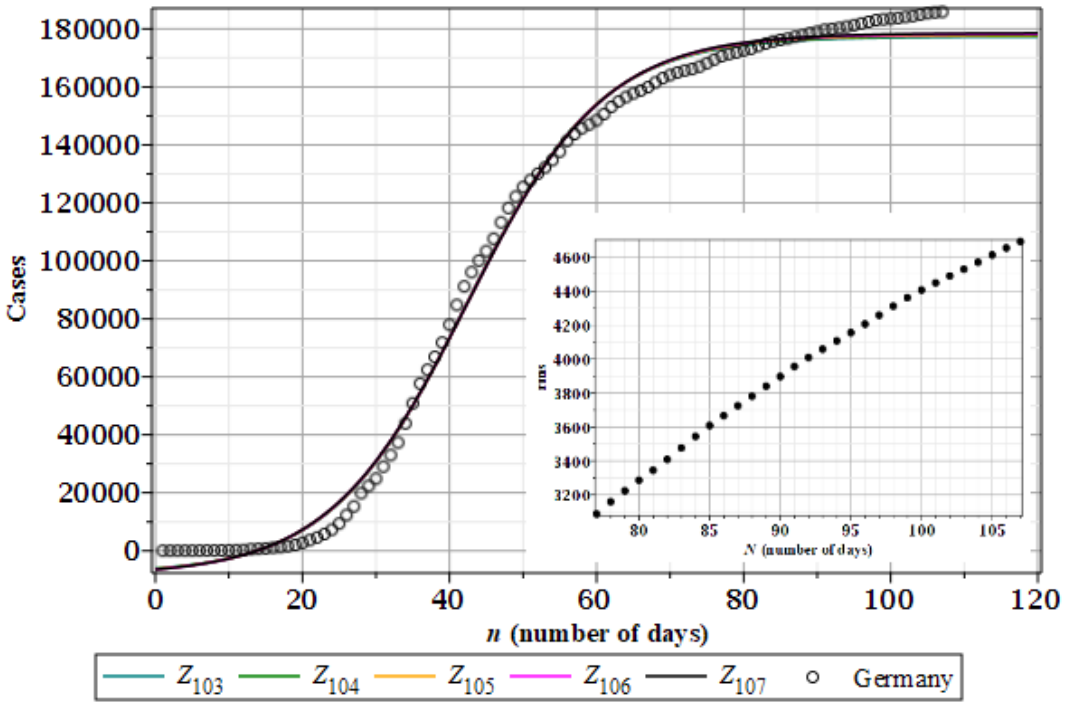


FIG. 26: Daily Covid-19 case curves and rms for the data from Germany. $Z_{107}(n) = 91976\tanh(0.055n - 2.338) + 84432$.

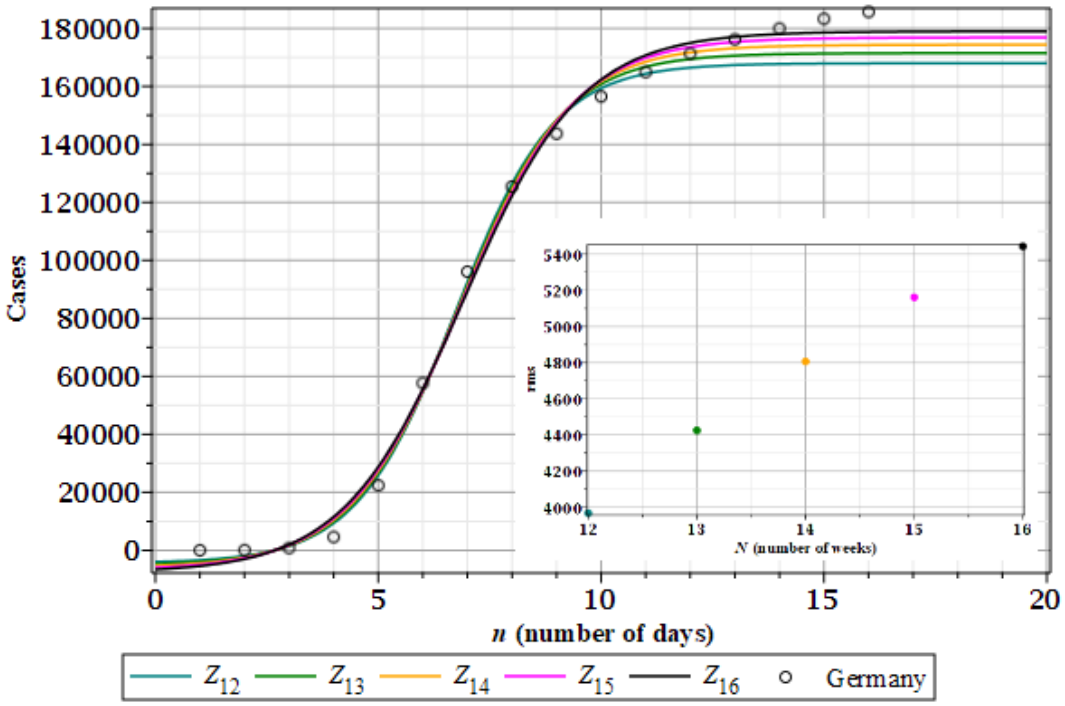


FIG. 27: Weekly Covid-19 case curves for the data from Germany. $Z_{16}(n) = 93321\tanh(0.374n - 2.579) + 85680$.

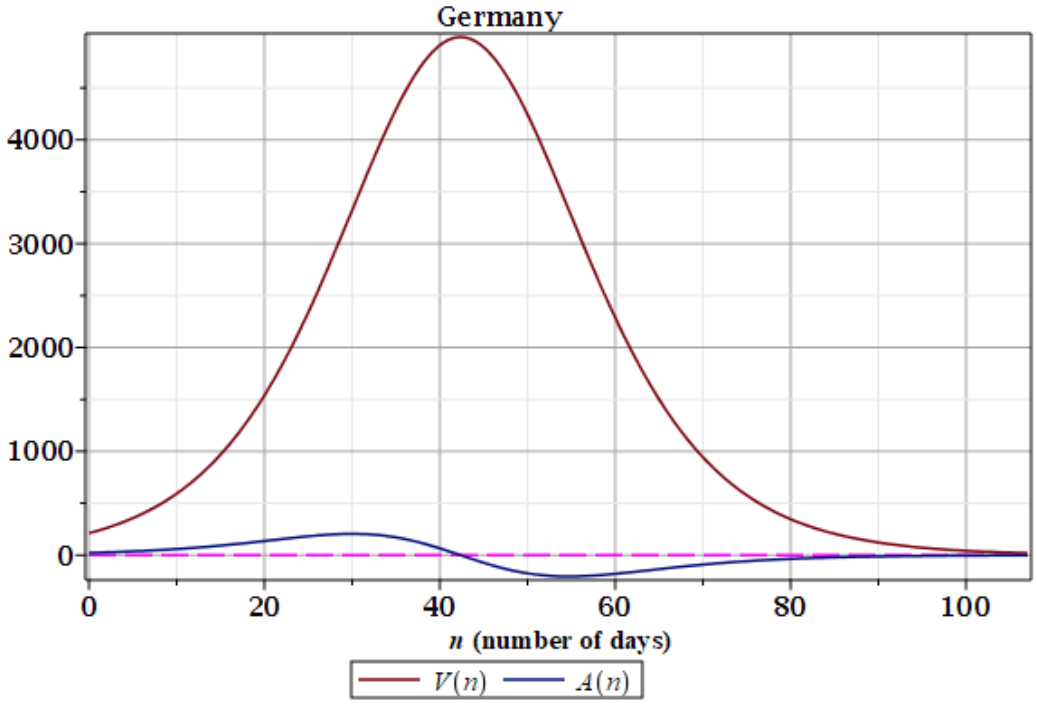


FIG. 28: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{107}. Complete curves. Inflection point: $n \approx 42$.

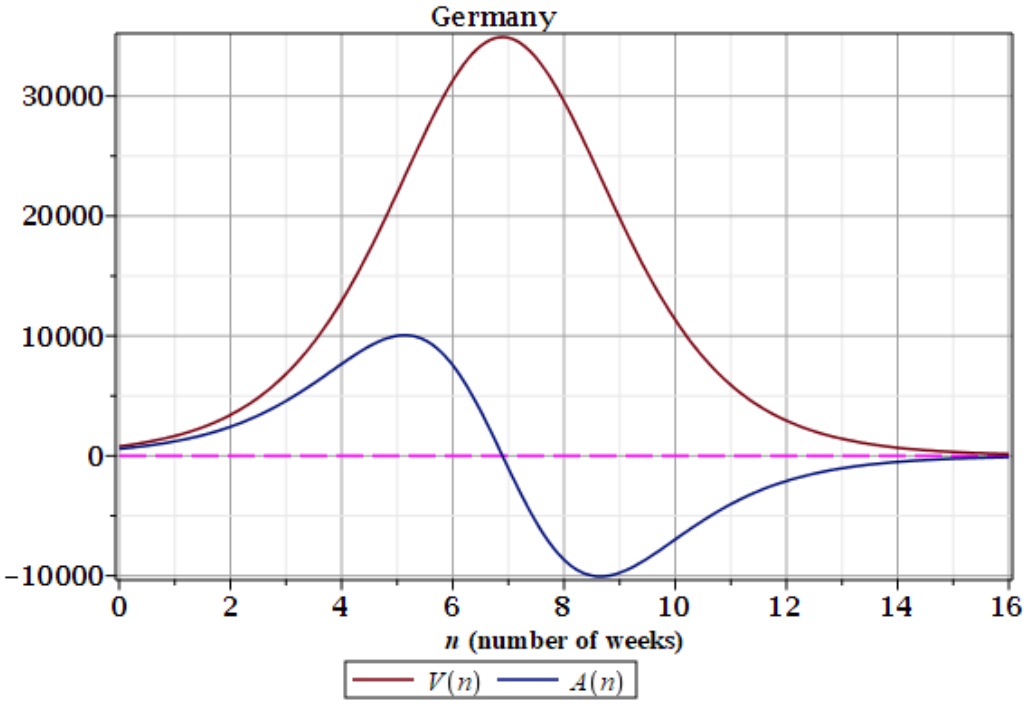


FIG. 29: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{16}. Complete curves. Inflection point: $n \approx 6.9$.

VI.8. Japan

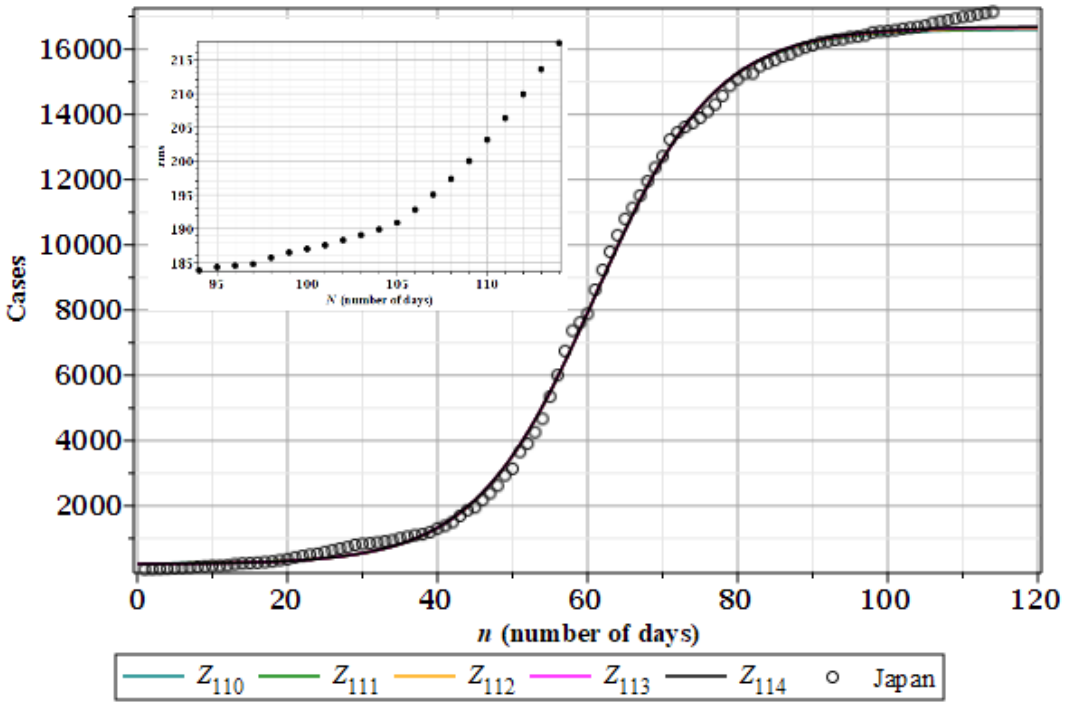


FIG. 30: Daily Covid-19 case curves and rms for the data from Japan. $Z_{114}(n) = 8243\tanh(0.062n - 3.793) + 8453$.

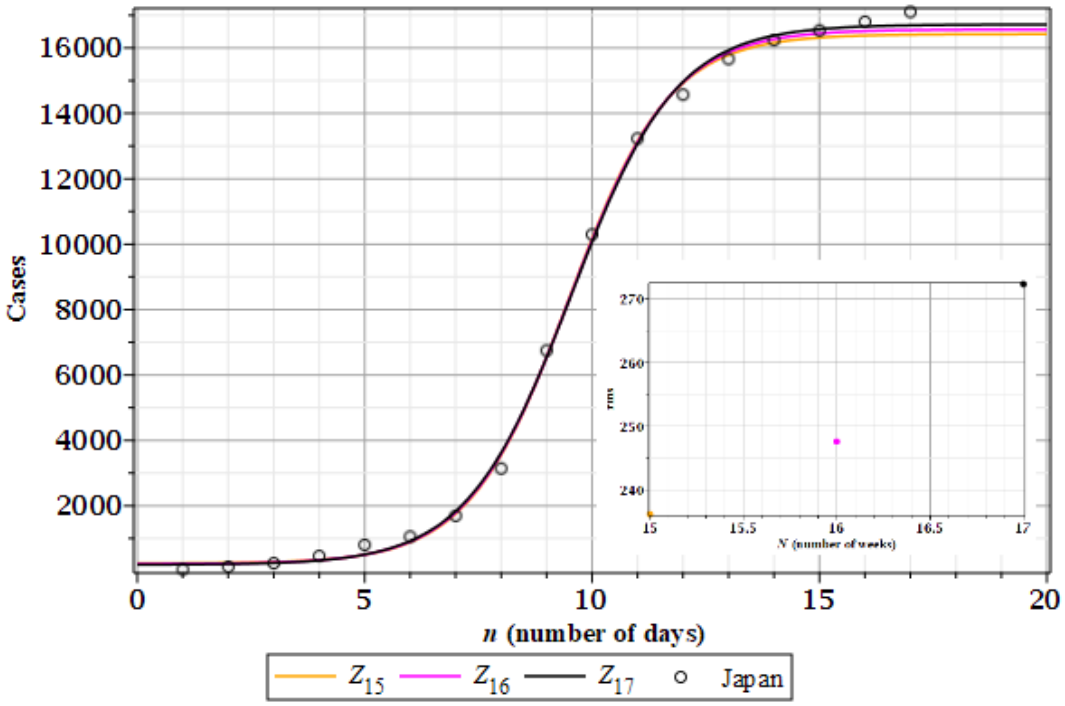


FIG. 31: Weekly Covid-19 case curves for the data from Japan. $Z_{17}(n) = 8262\tanh(0.434n - 4.143) + 8456$.

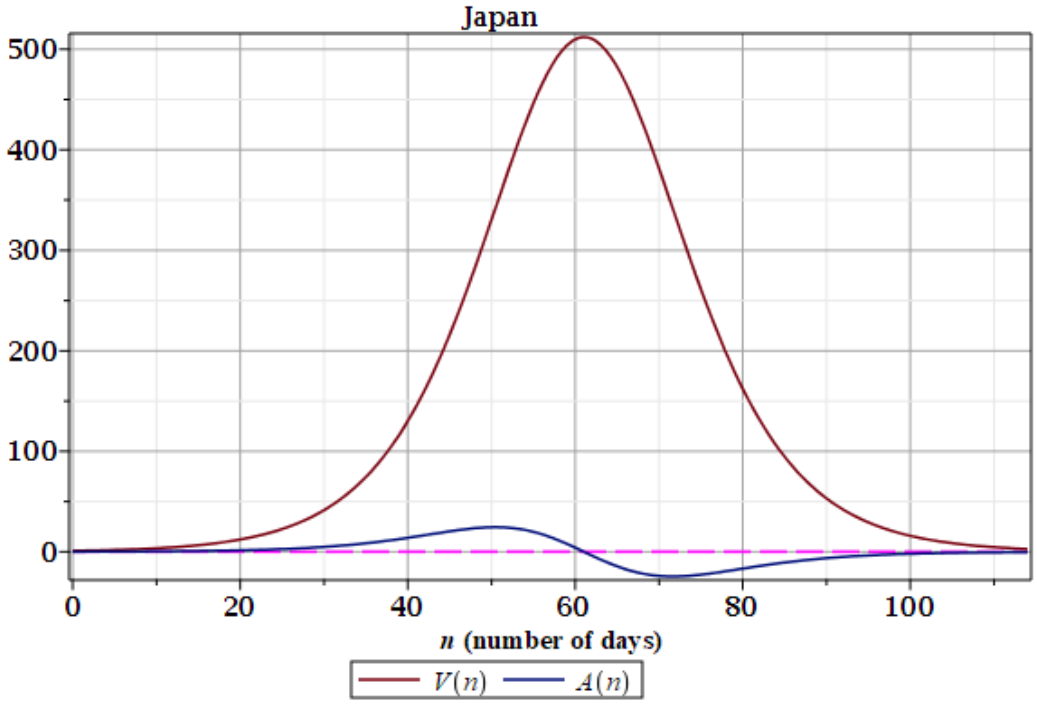


FIG. 32: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{114}. Complete curves. Inflection point: $n \approx 61$.

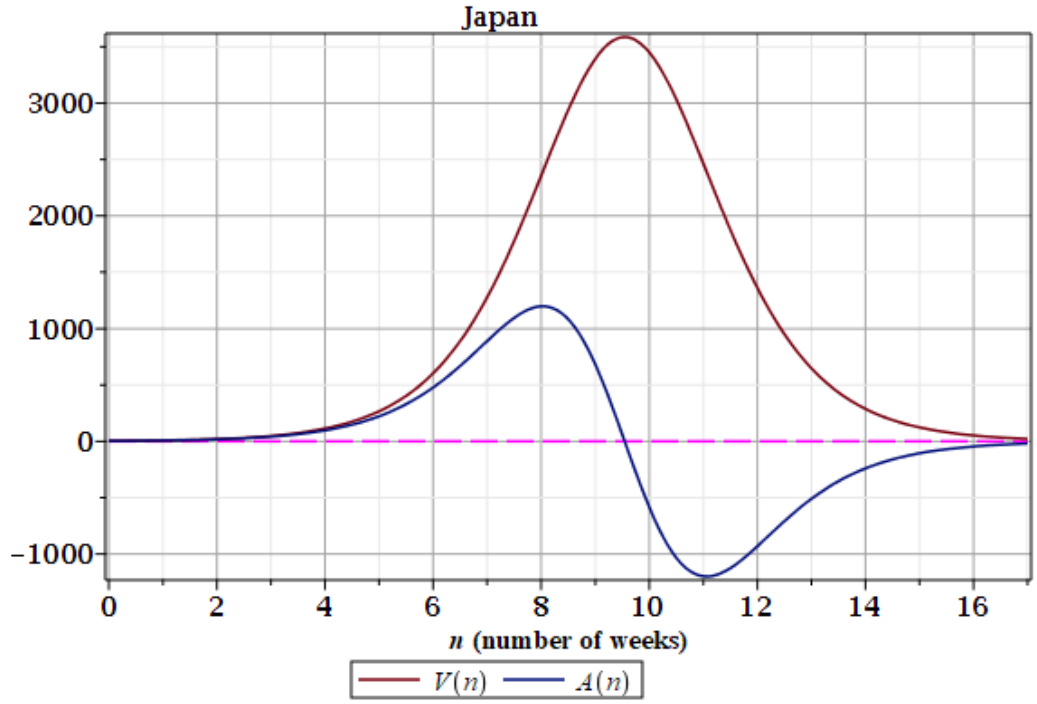


FIG. 33: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{17}. Complete curves. Inflection point: $n \approx 9.5$.

VI.9. USA

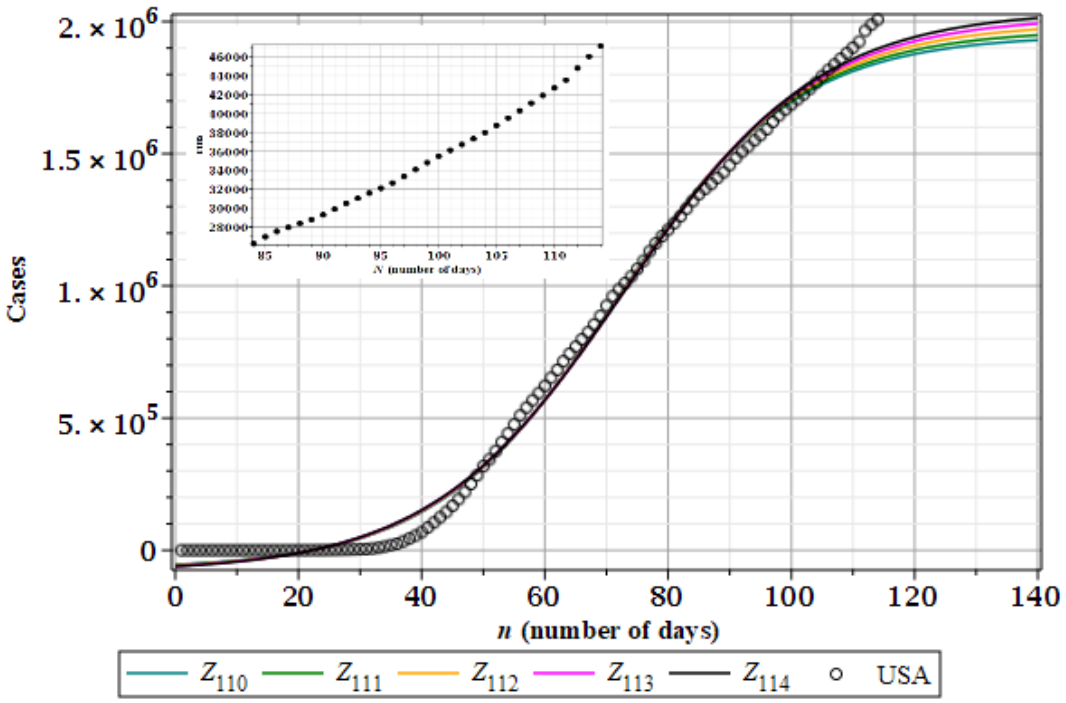


FIG. 34: Daily Covid-19 case curves and rms for the data from USA.

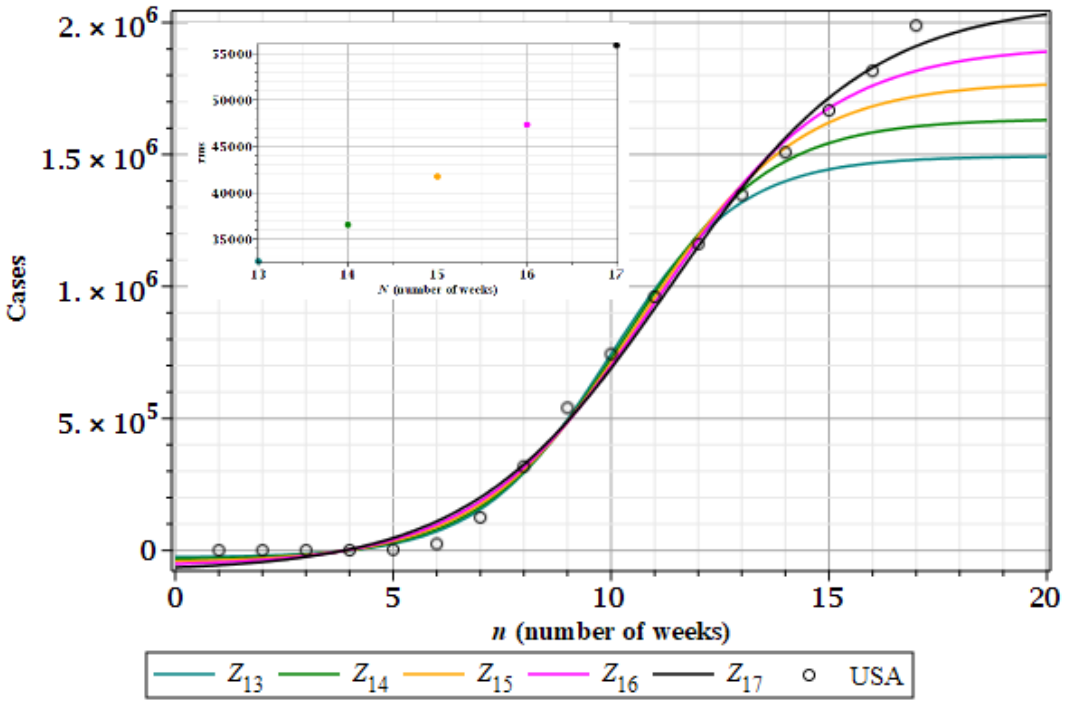


FIG. 35: Weekly Covid-19 case curves and rms for the data from USA.

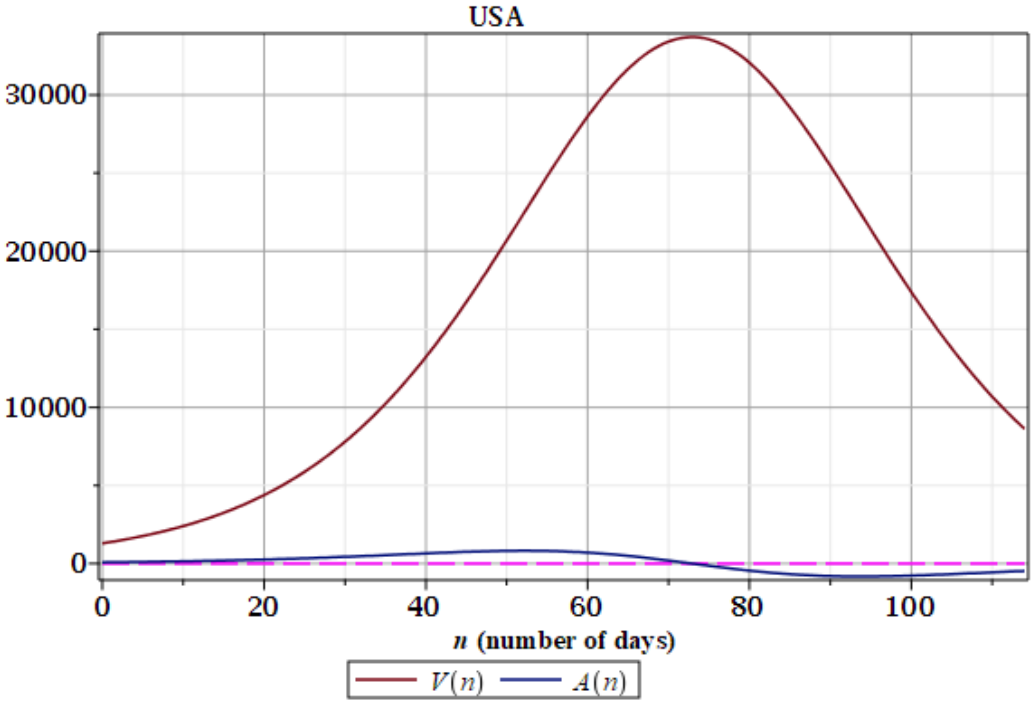


FIG. 36: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{114}. Incomplete curves. Inflection point: $n \approx 73$.

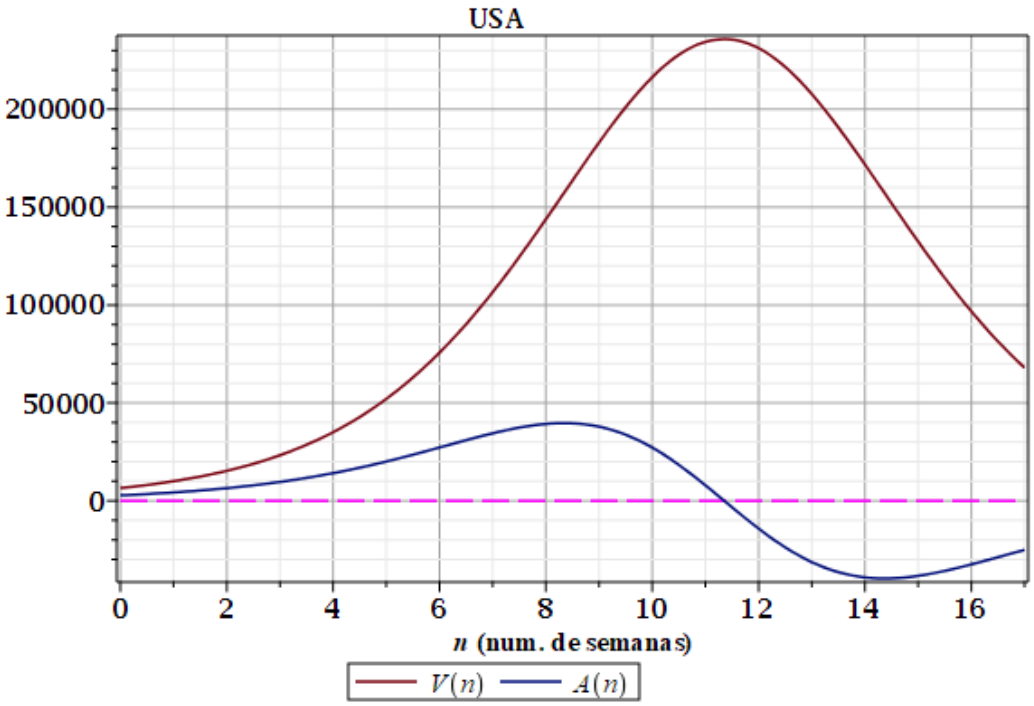


FIG. 37: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{17}. Incomplete curves. Inflection point: $n \approx 11.4$.

VI.10. Russia

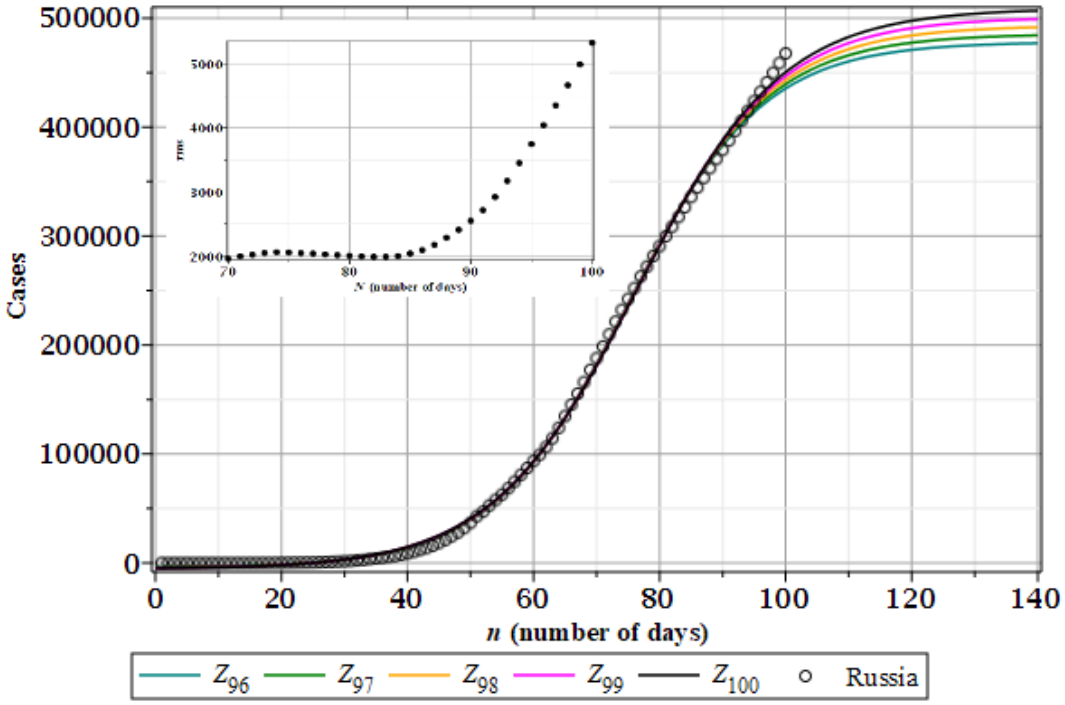


FIG. 38: Daily Covid-19 case curves and rms for the data from Russia.

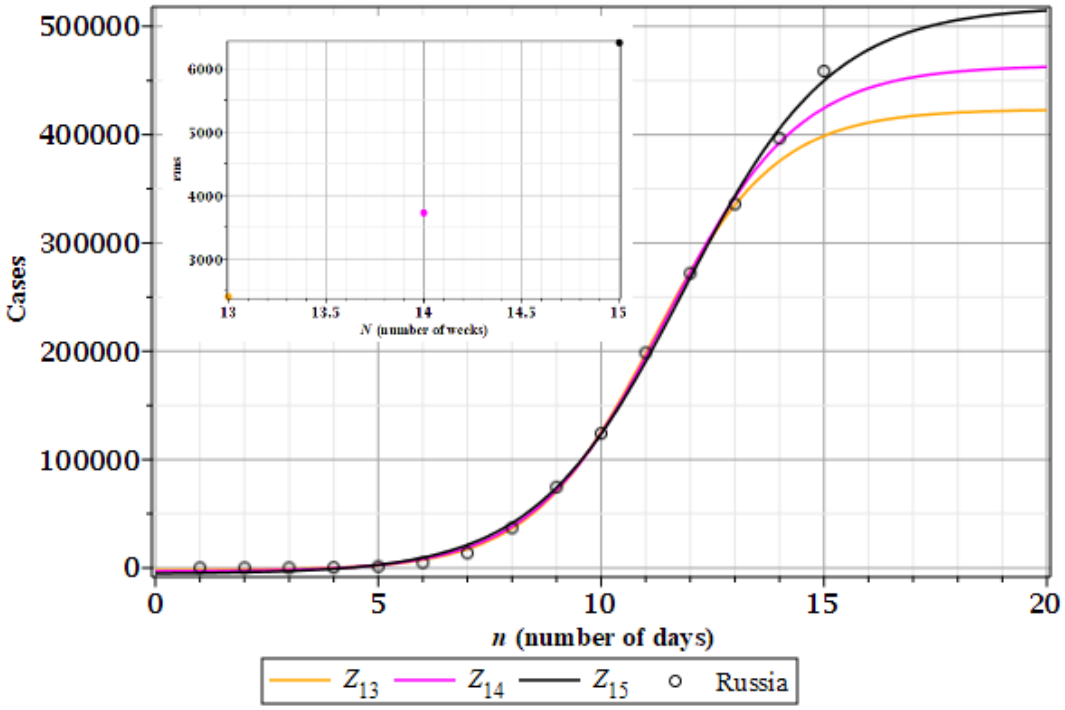


FIG. 39: Weekly Covid-19 case curves and rms for the data from Russia.

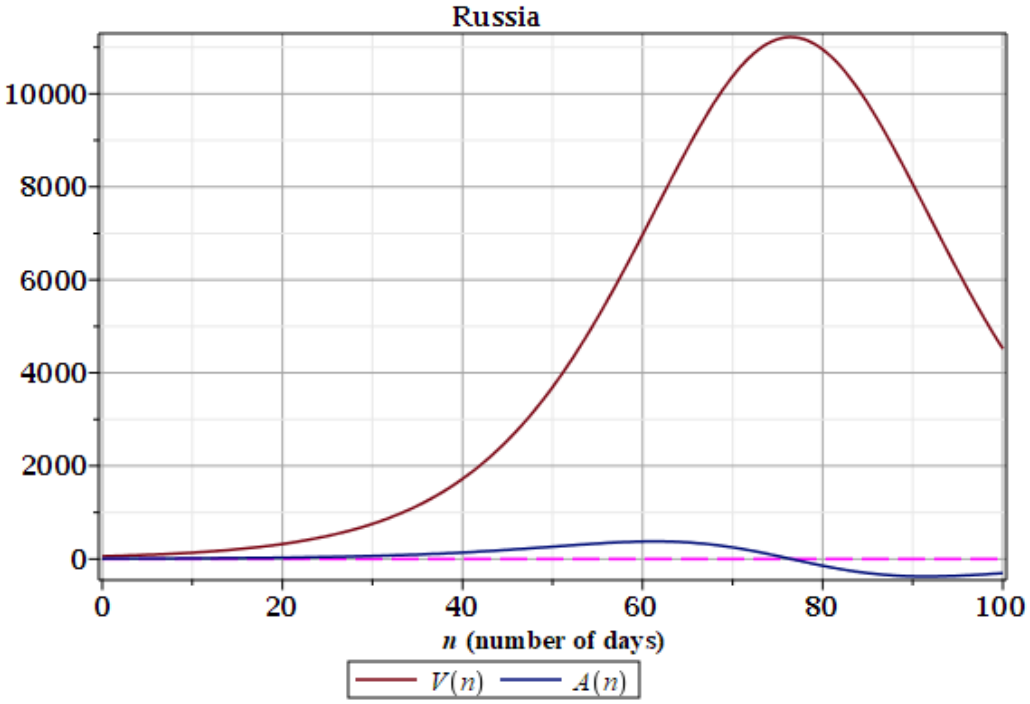


FIG. 40: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{93}. Incomplete curves. Inflection point: $n \approx 74$.

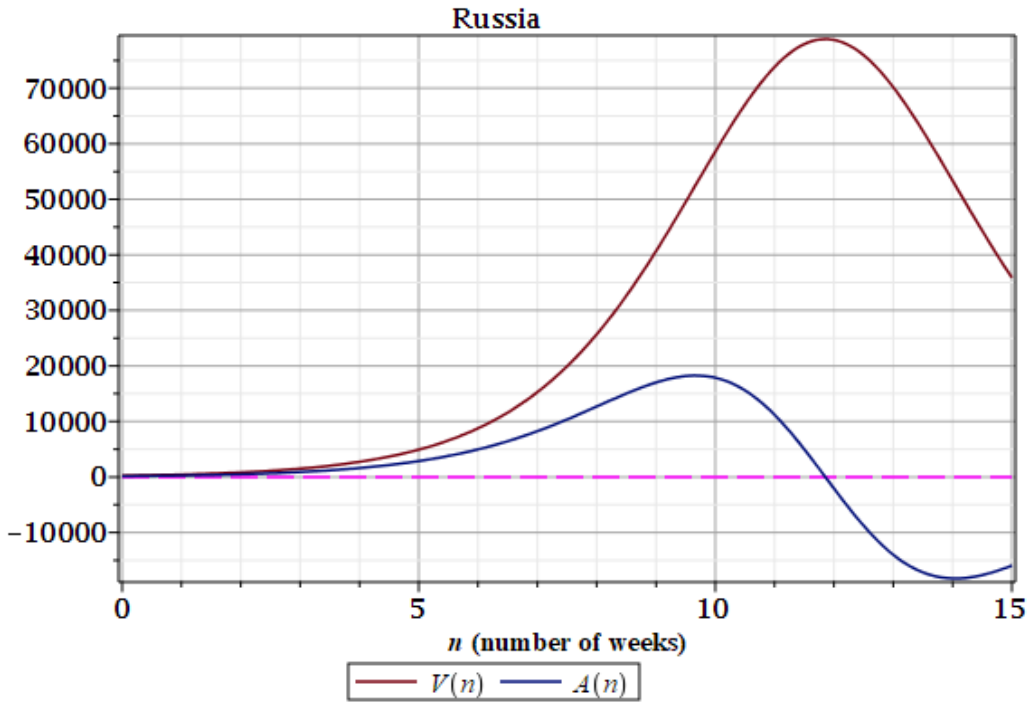


FIG. 41: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{14}. Incomplete curves. Inflection point: $n \approx 11.5$.

VI.11. UK

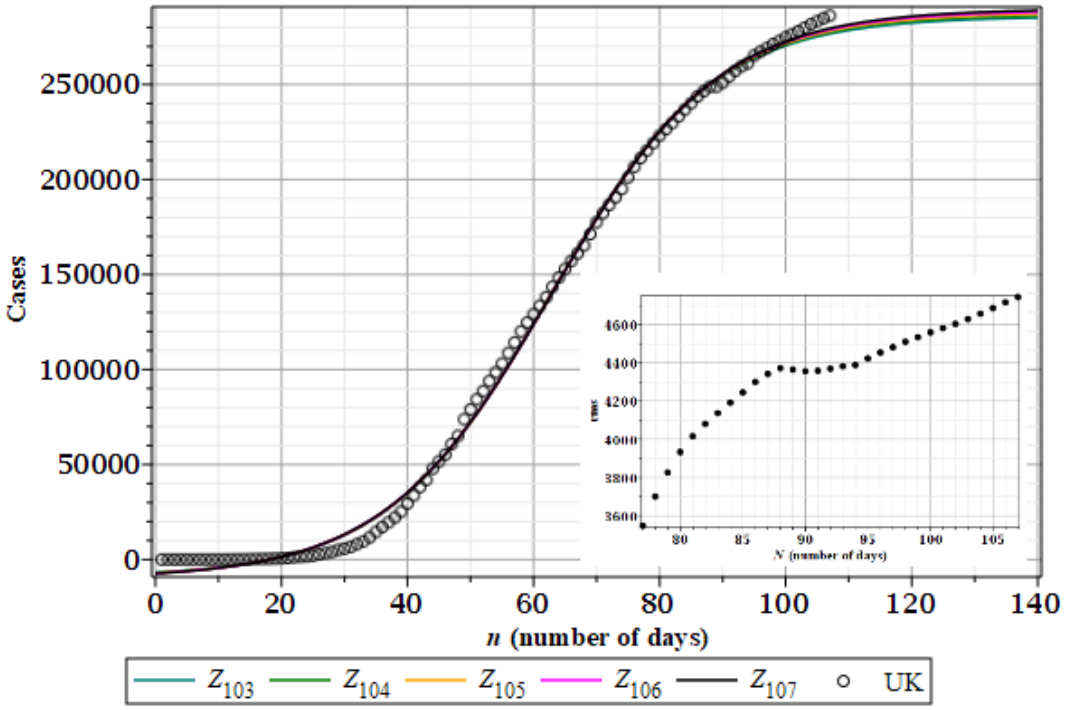


FIG. 42: Daily Covid-19 case curves and rms for the data from UK.

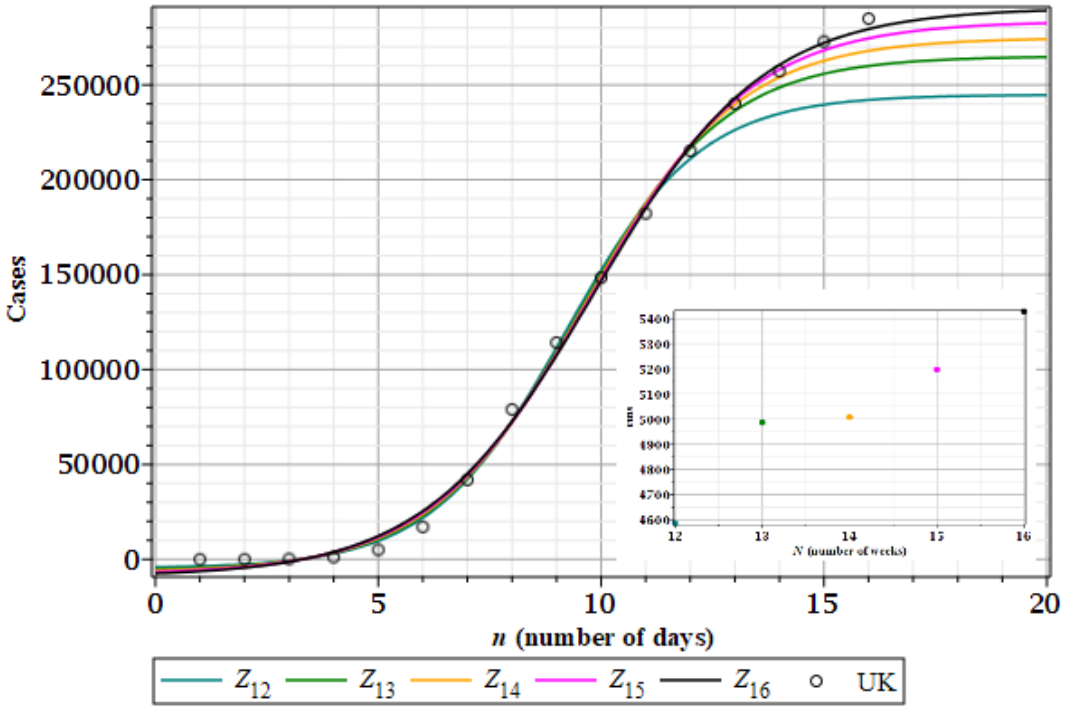


FIG. 43: Weekly Covid-19 case curves and rms for the data from UK.

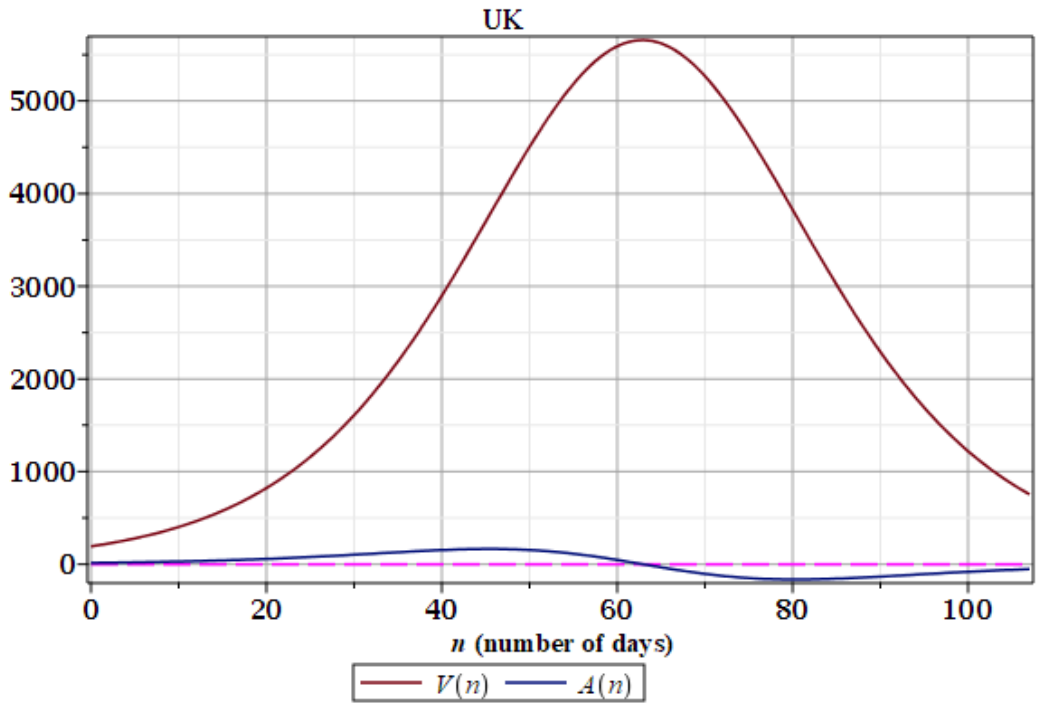


FIG. 44: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{107}. Incomplete curves. Inflection point: $n \approx 63$.

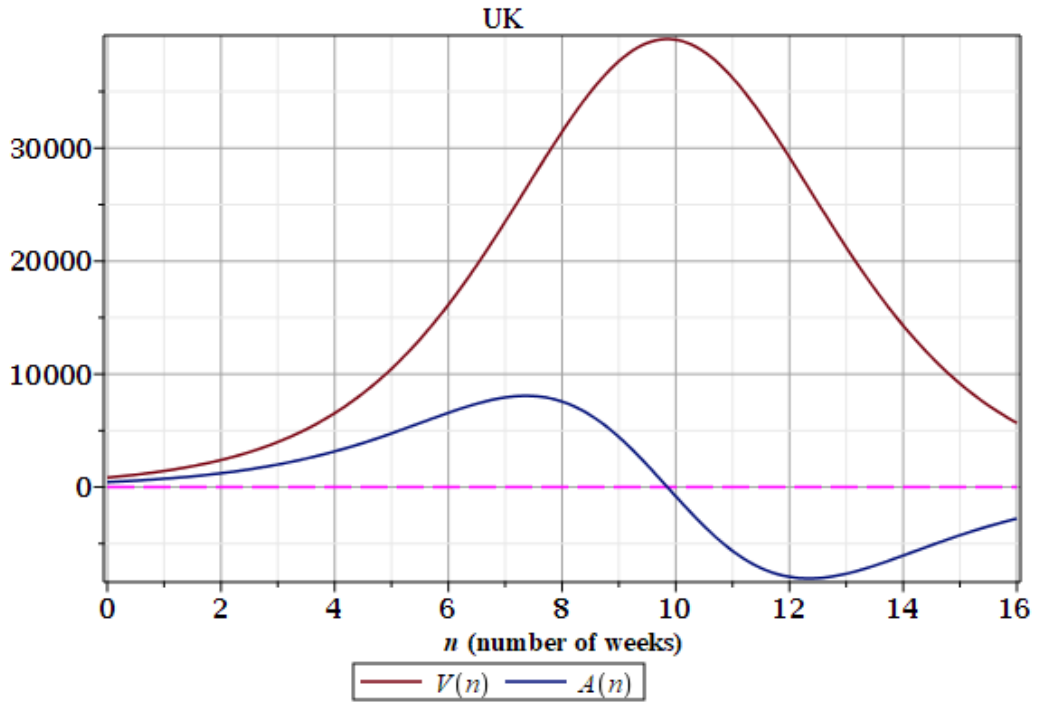


FIG. 45: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{16}.Incomplete curves. Inflection point: $n \approx 9.8$.

VI.12. Peru

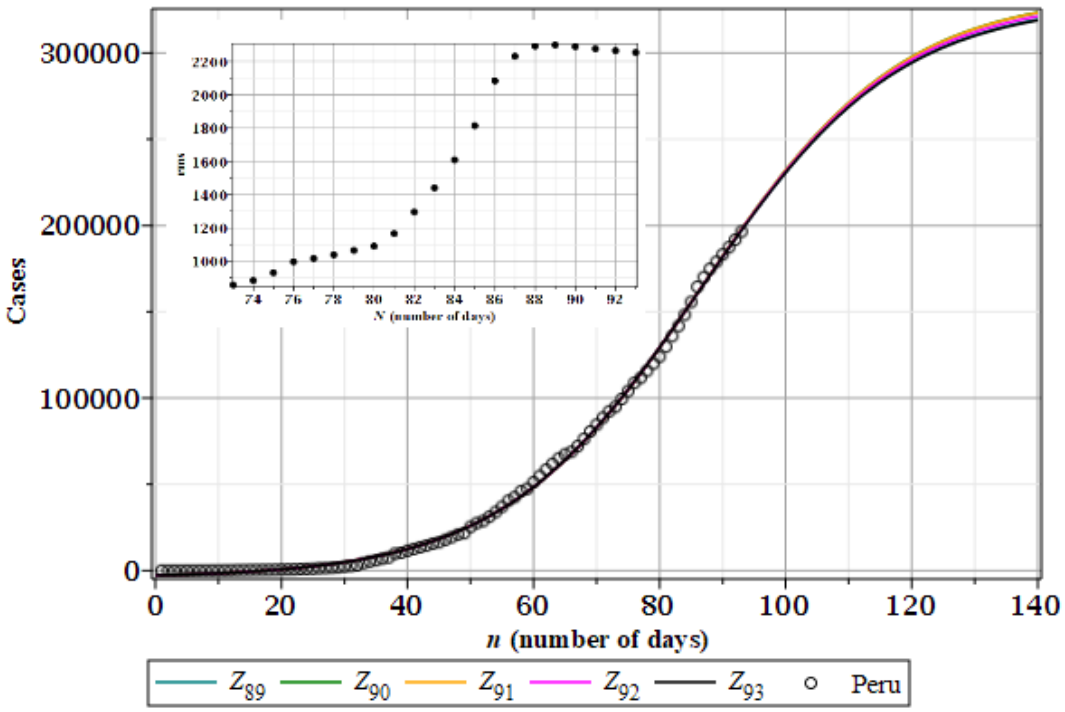


FIG. 46: Daily Covid-19 case curves and rms for the data from Peru.

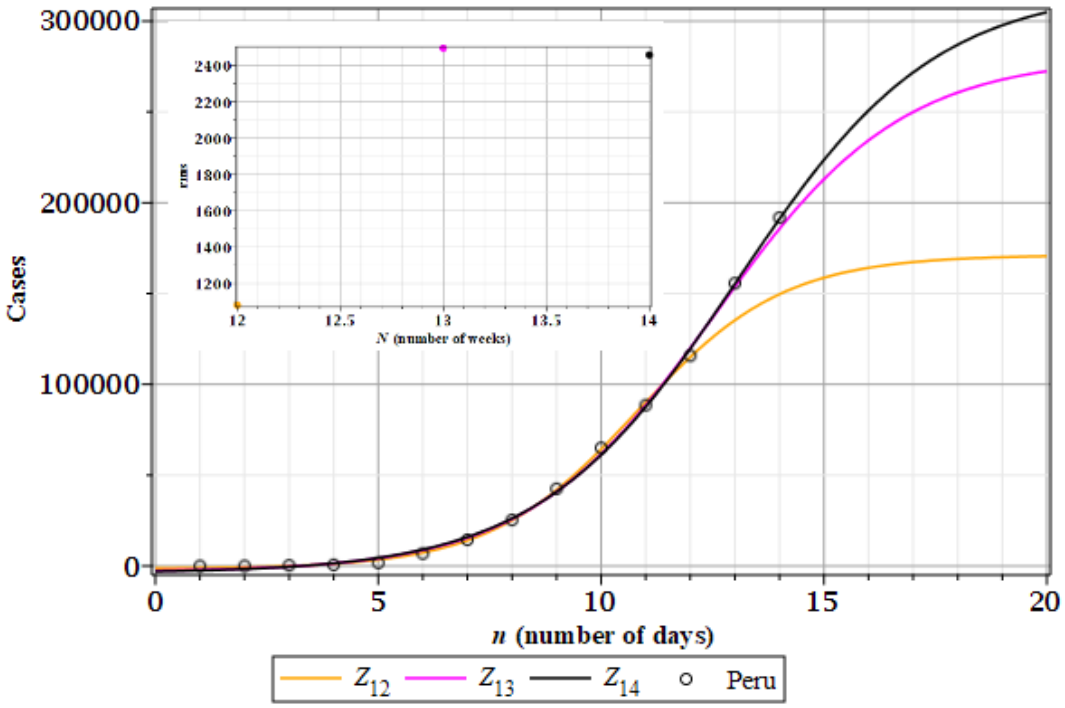


FIG. 47: Weekly Covid-19 case curves and rms for the data from Peru.

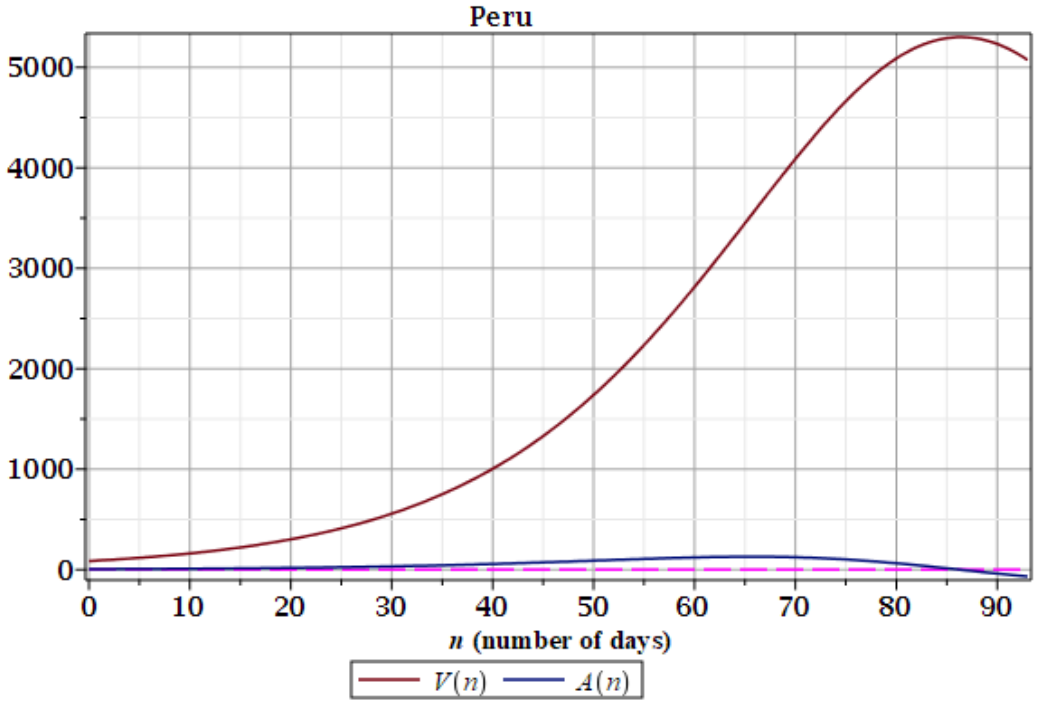


FIG. 48: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{93}. Incomplete curves. Inflection point: $n \approx 86$.

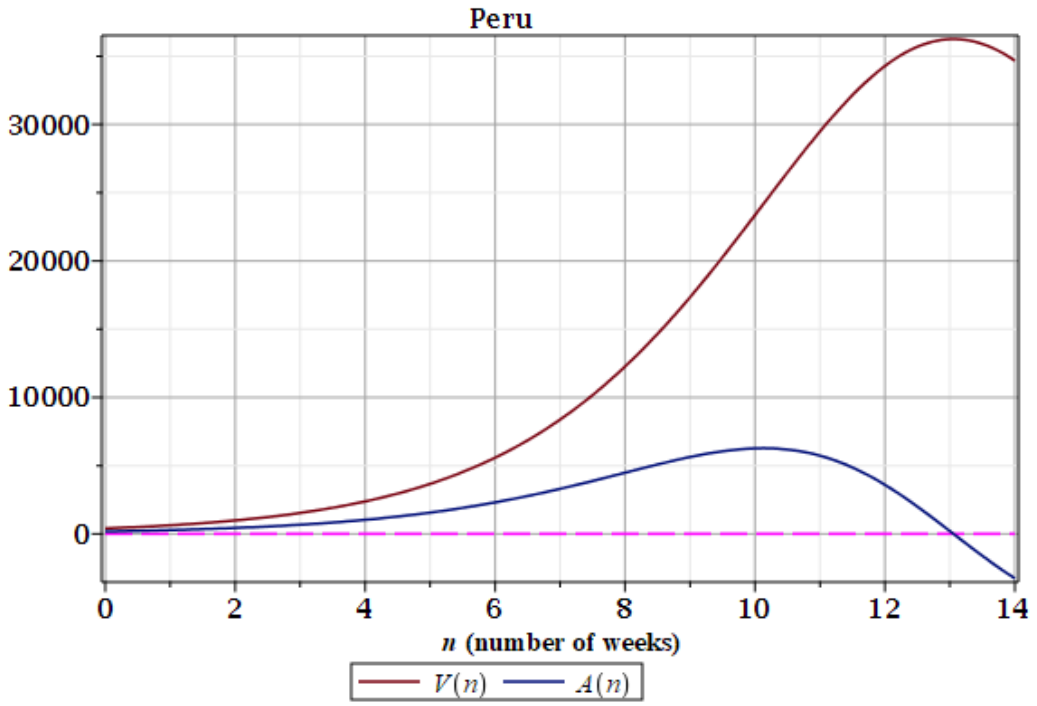


FIG. 49: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{14}. Incomplete curves. Inflection point: $n \approx 13$.

VI.13. Turkey

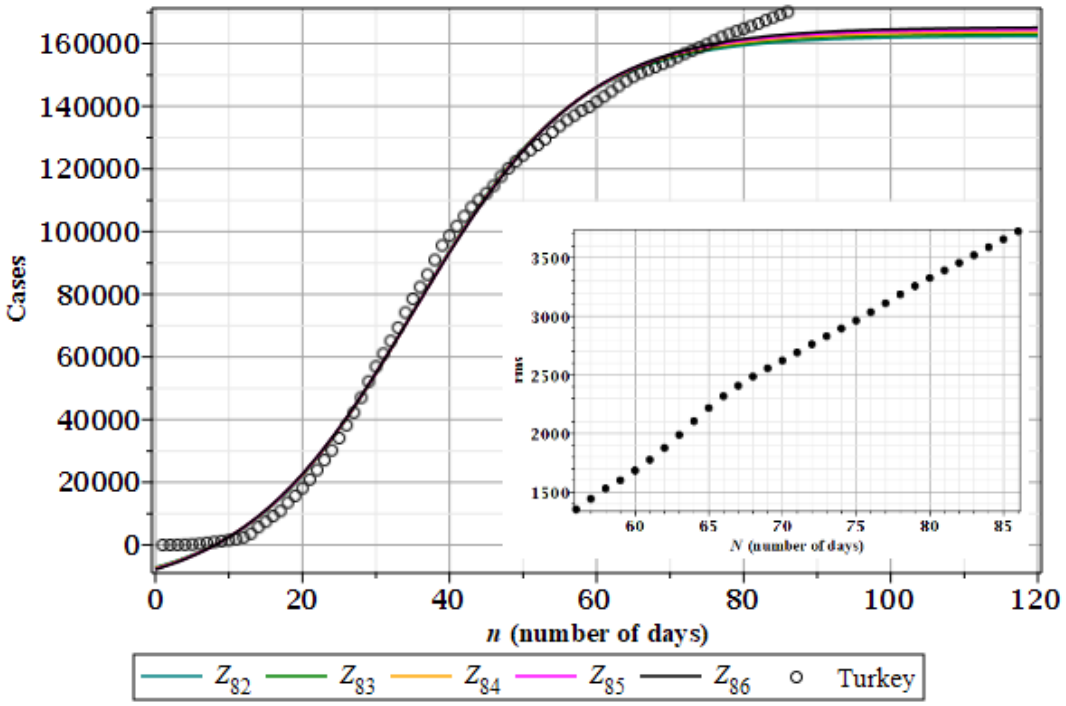


FIG. 50: Daily Covid-19 case curves and rms for the data from Turkey.

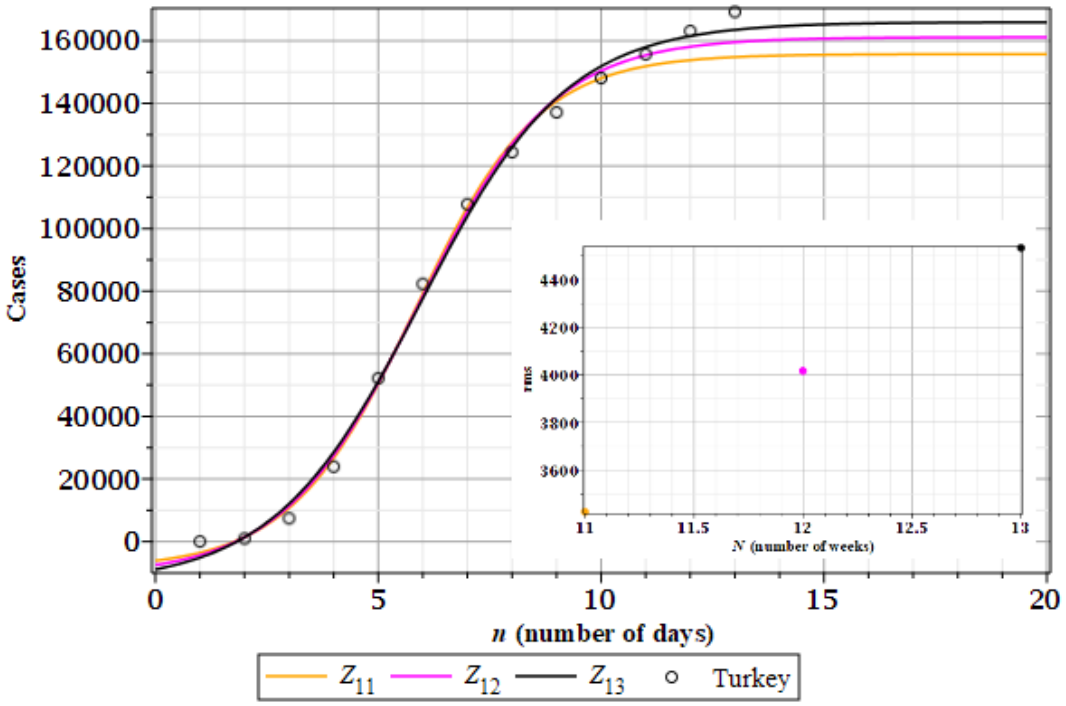


FIG. 51: Weekly Covid-19 case curves and rms for the data from Turkey.

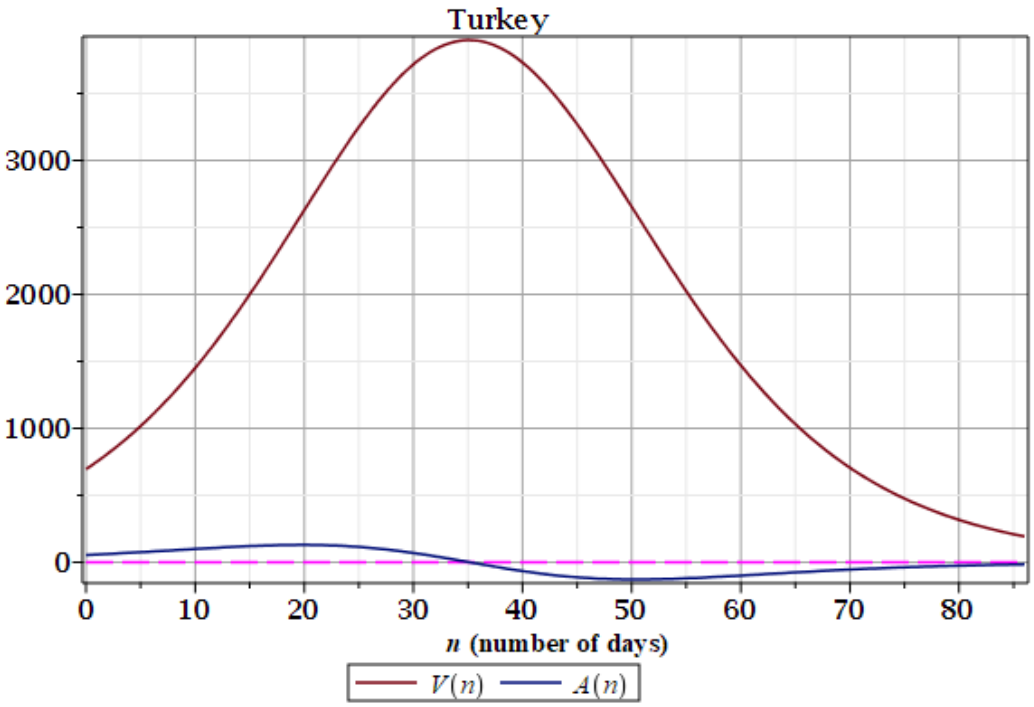


FIG. 52: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{86}. Incomplete curves. Inflection point: $n \approx 35$.

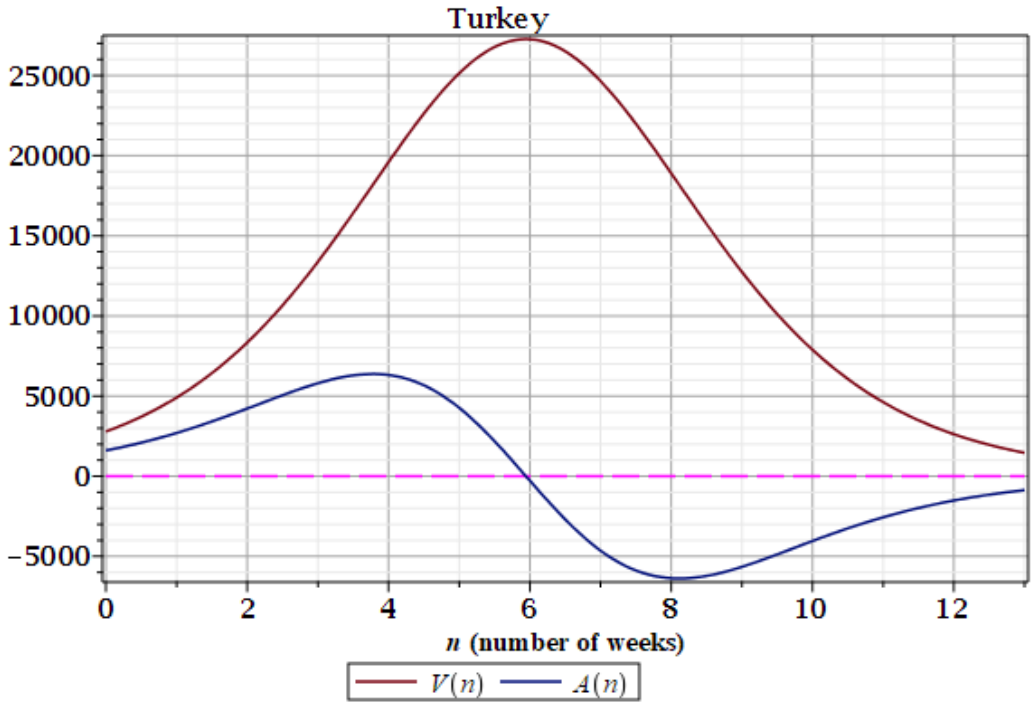


FIG. 53: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{13}. Incomplete curves. Inflection point: $n \approx 5.9$.

VI.14. Mexico

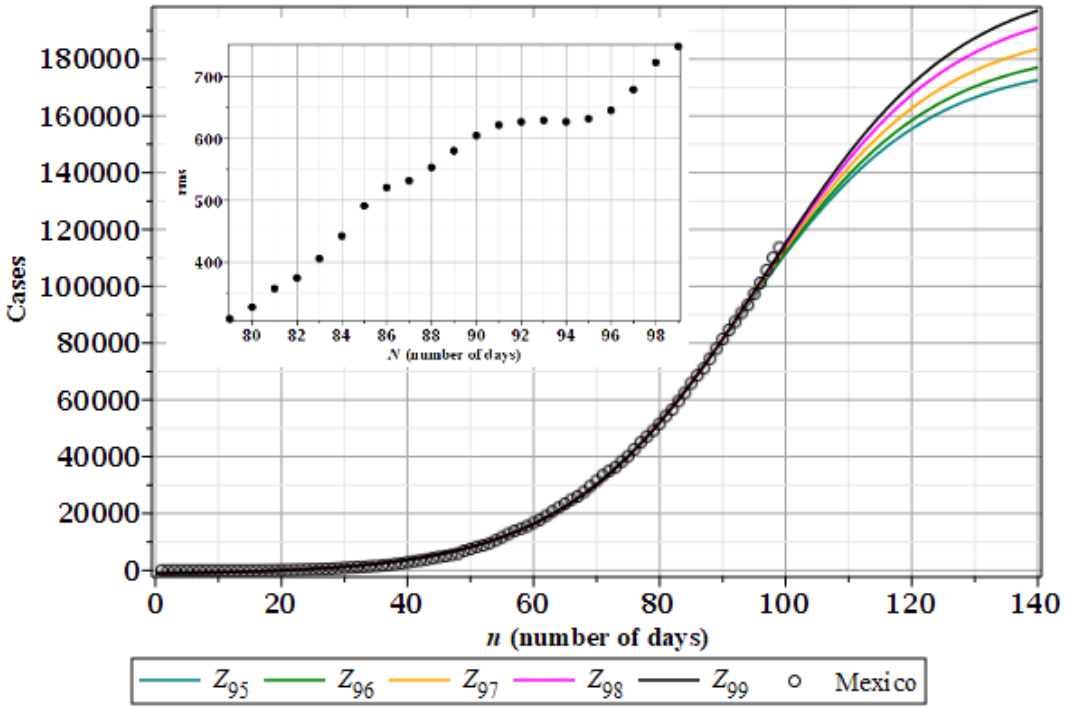


FIG. 54: Daily Covid-19 case curves and rms for the data from Mexico

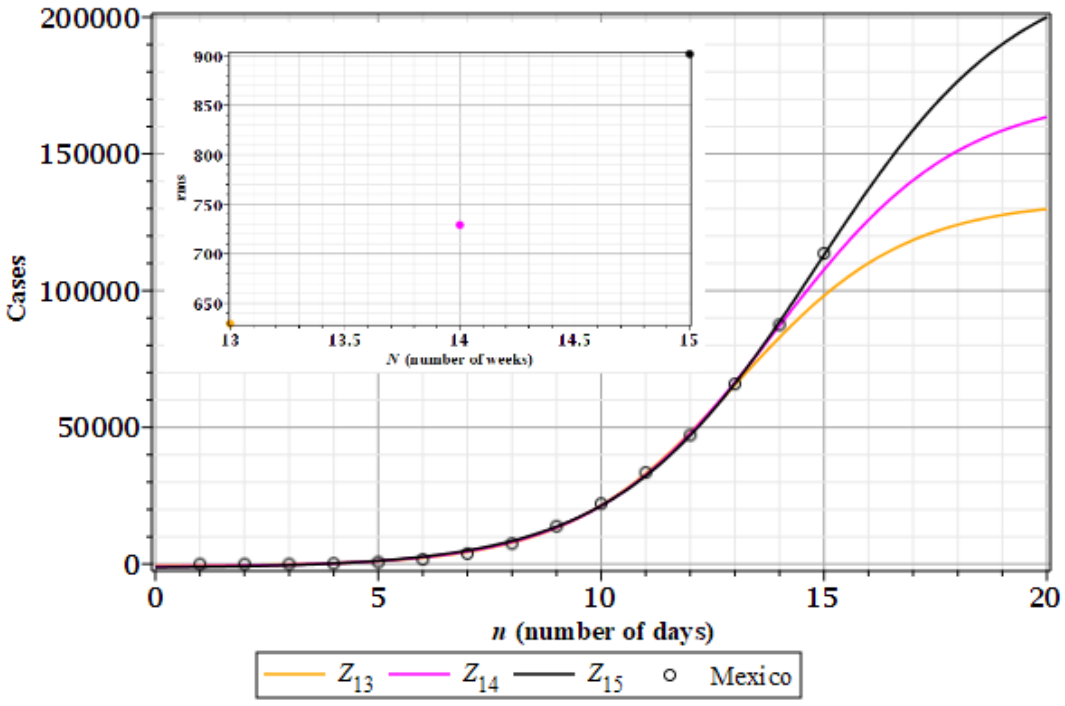


FIG. 55: Weekly Covid-19 case curves and rms for the data from Mexico.

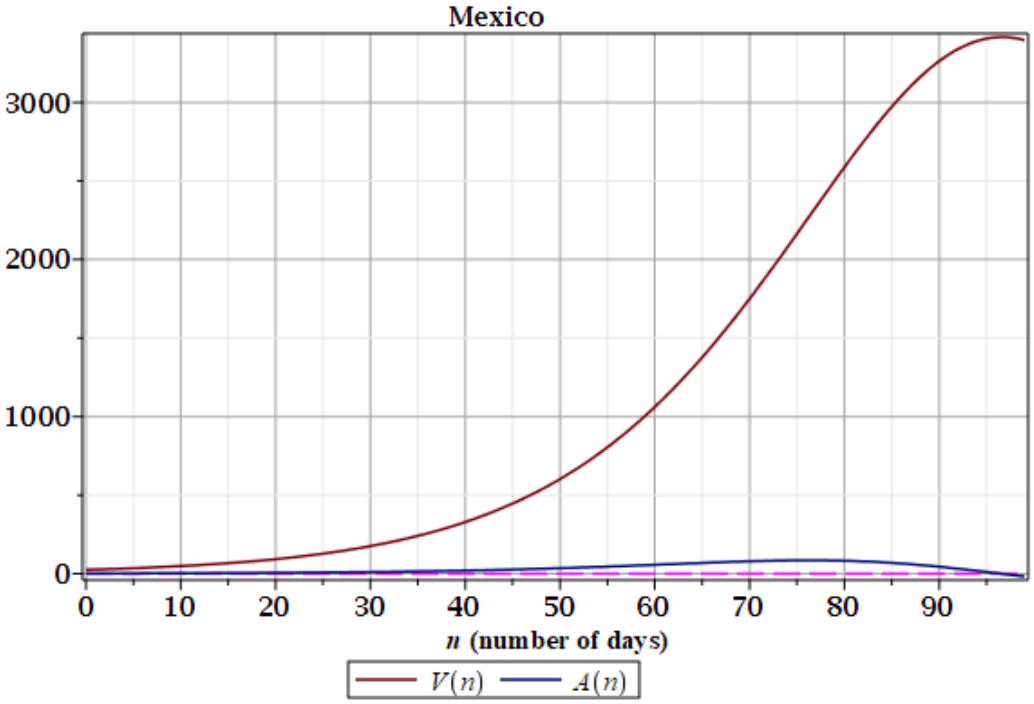


FIG. 56: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{99}. Incomplete curves. Inflection point: $n \approx 97$.

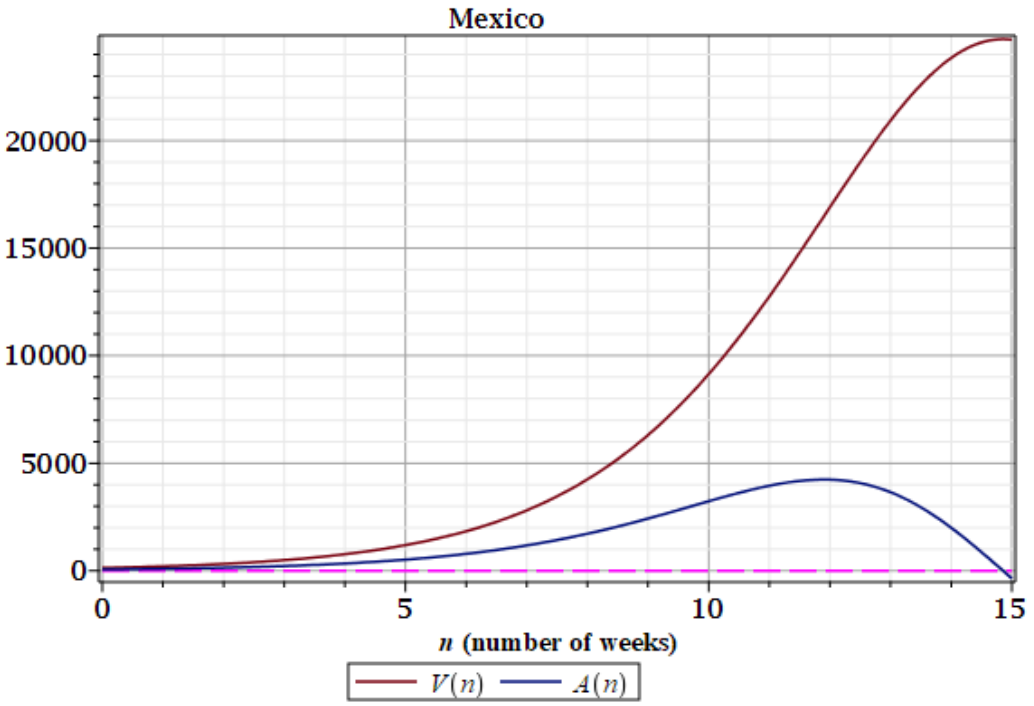


FIG. 57: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{15}. Incomplete curves. Inflection point: $n \approx 14.8$.

VI.15. Saudi Arabia

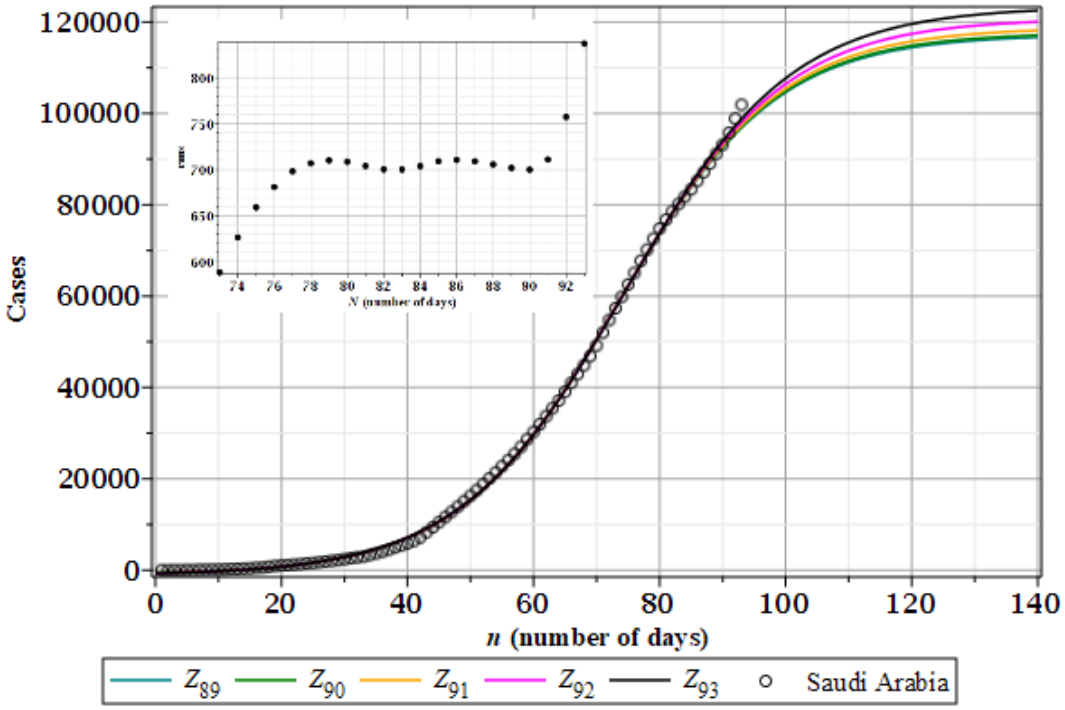


FIG. 58: Daily Covid-19 case curves and rms for the data from Saudi Arabia.

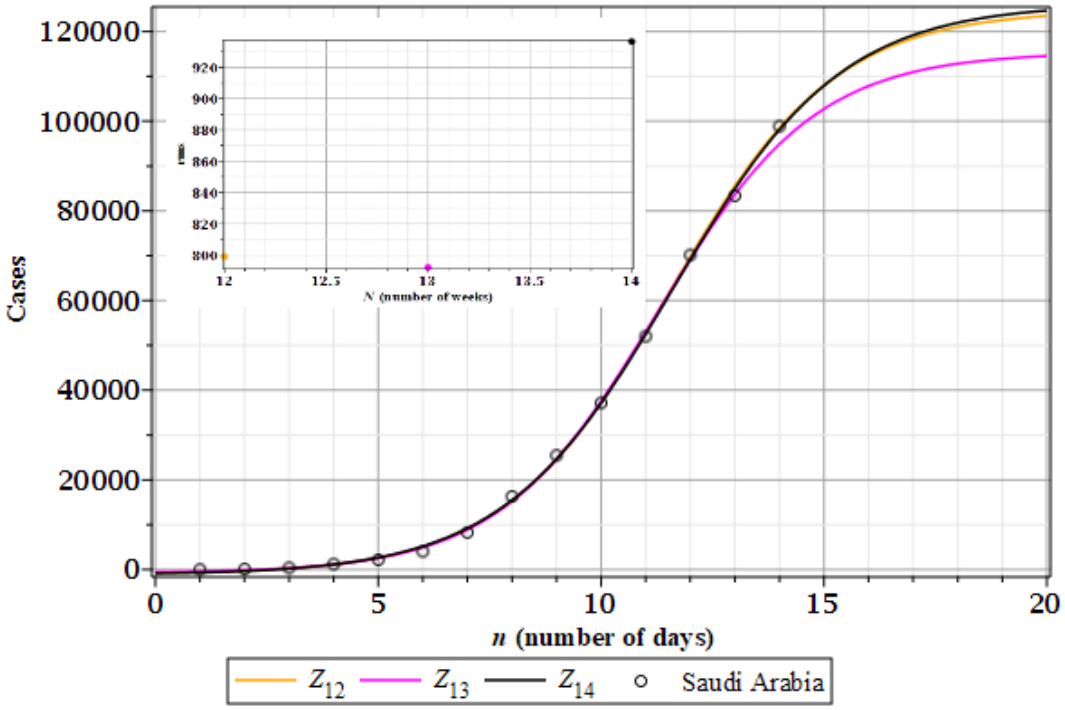


FIG. 59: Weekly Covid-19 case curves and rms for the data from Saudi Arabia.

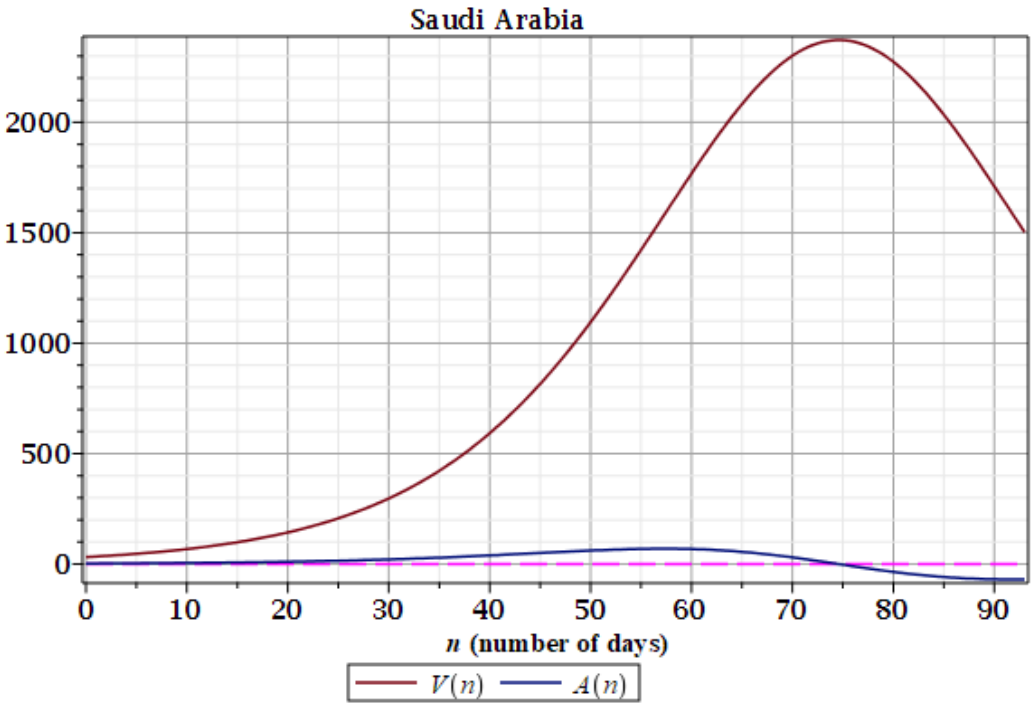


FIG. 60: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{93}. Incomplete curves. Inflection point: $n \approx 75$.

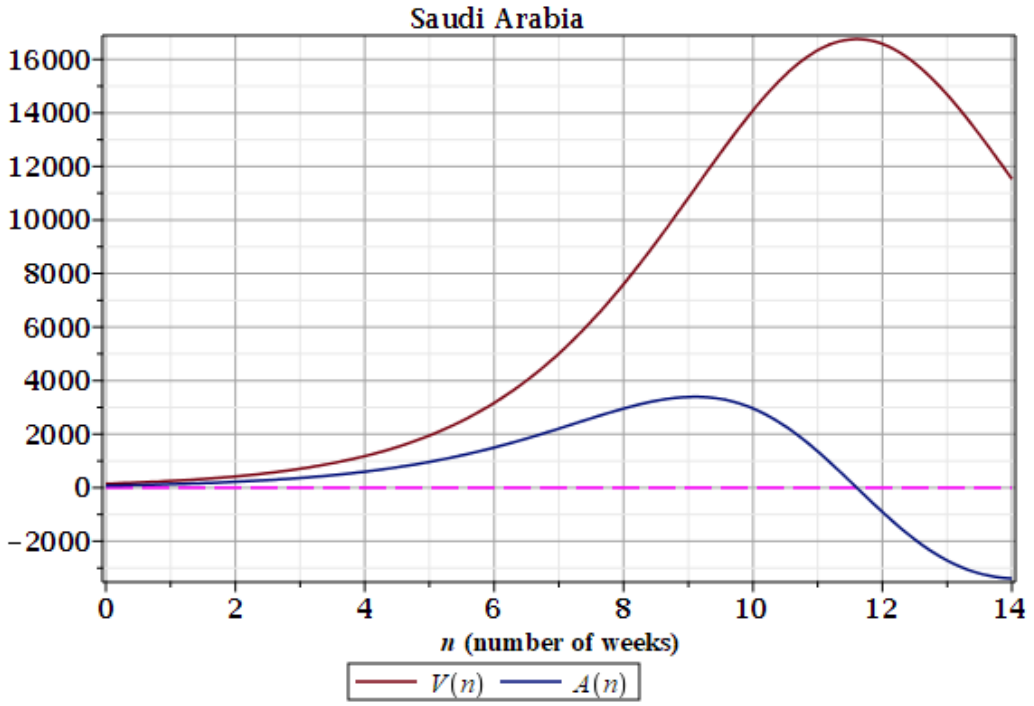


FIG. 61: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{14}. Incomplete curves. Inflection point: $n \approx 11.6$.

VI.16. Canada

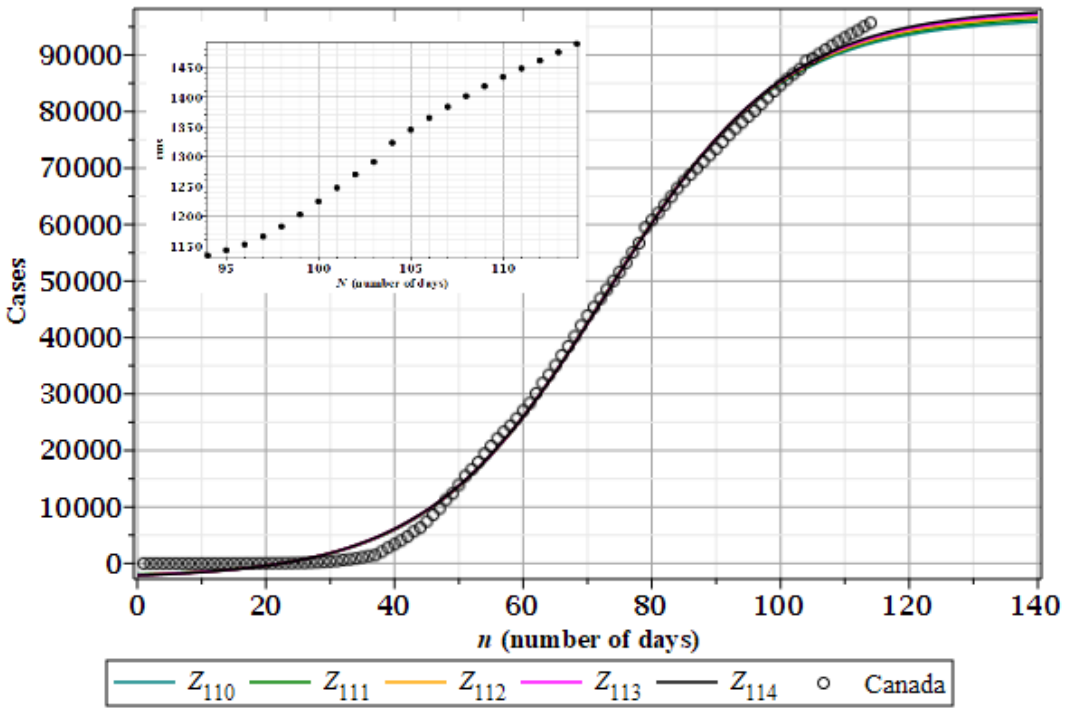


FIG. 62: Daily Covid-19 case curves and rms for the data from Canada.

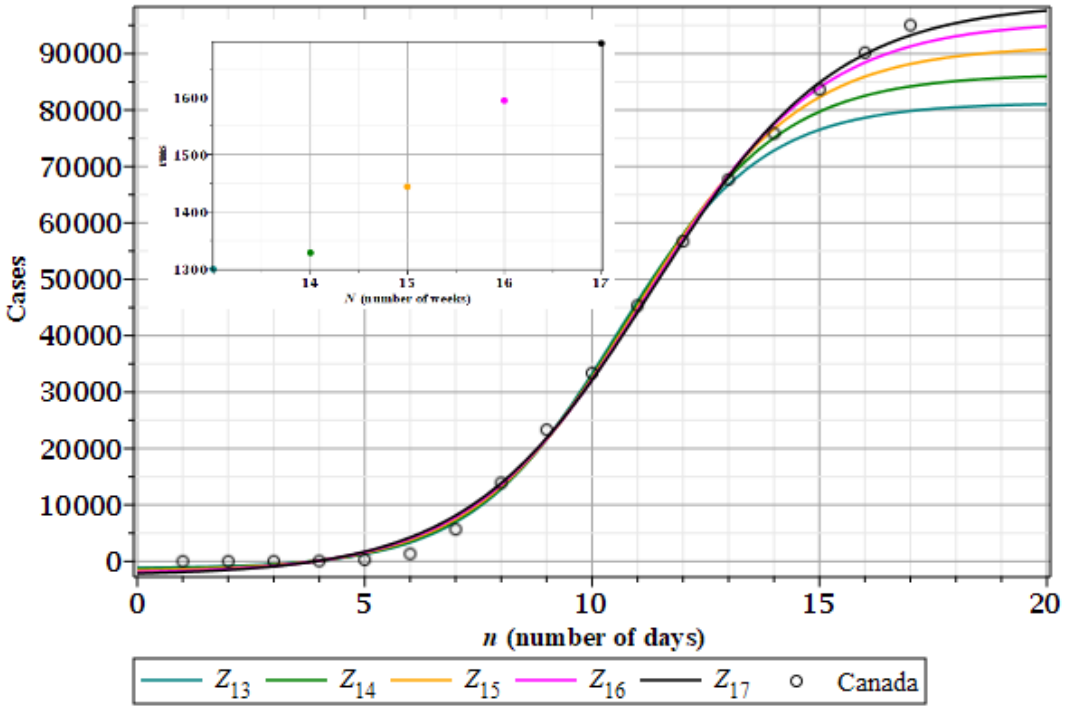


FIG. 63: Weekly Covid-19 case curves and rms for the data from Canada.

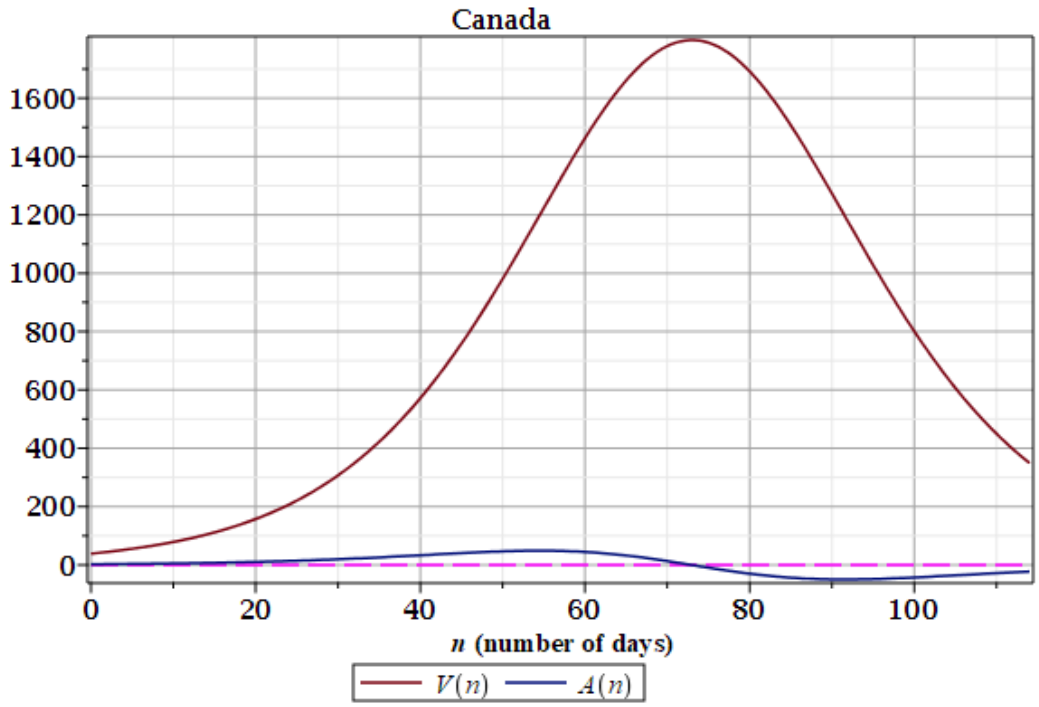


FIG. 64: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{114}. Incomplete curves. Inflection point: $n \approx 73$.

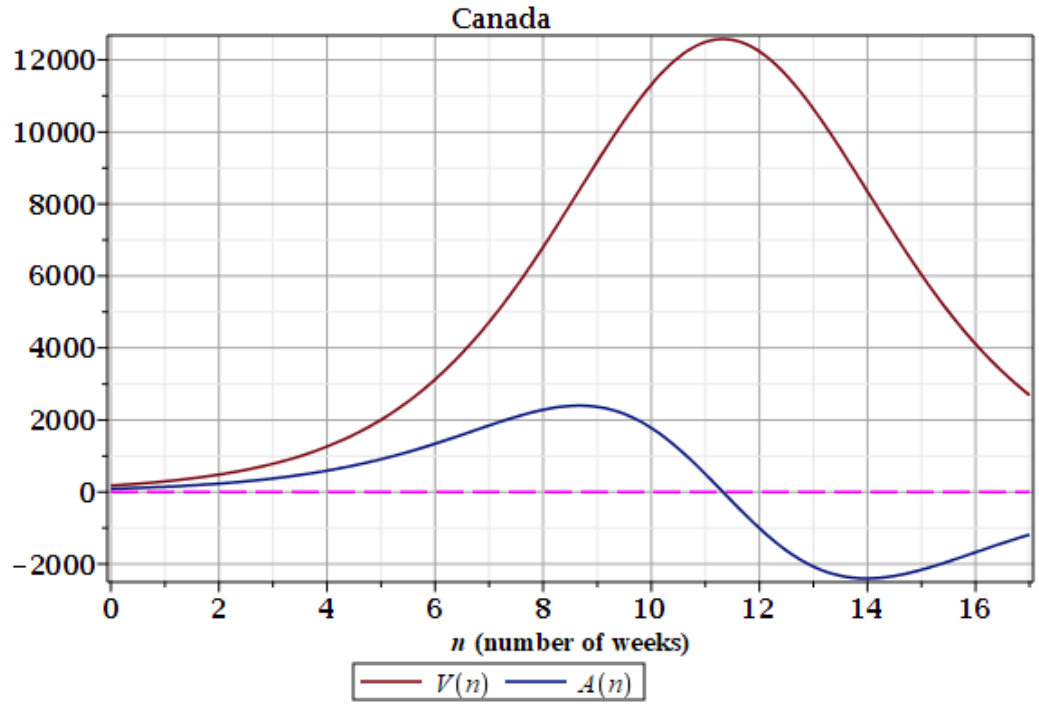


FIG. 65: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{17}. Incomplete curves. Inflection point: $n \approx 11.3$.

VI.17. Brazil

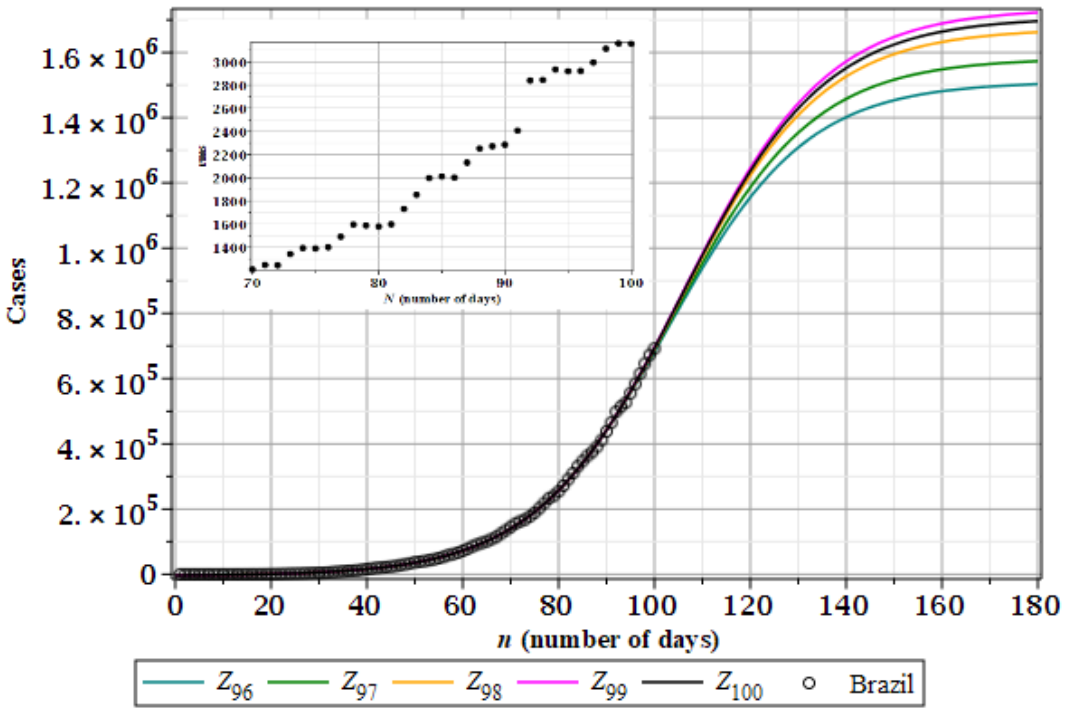


FIG. 66: Daily Covid-19 case curves and rms for the data from Brazil.

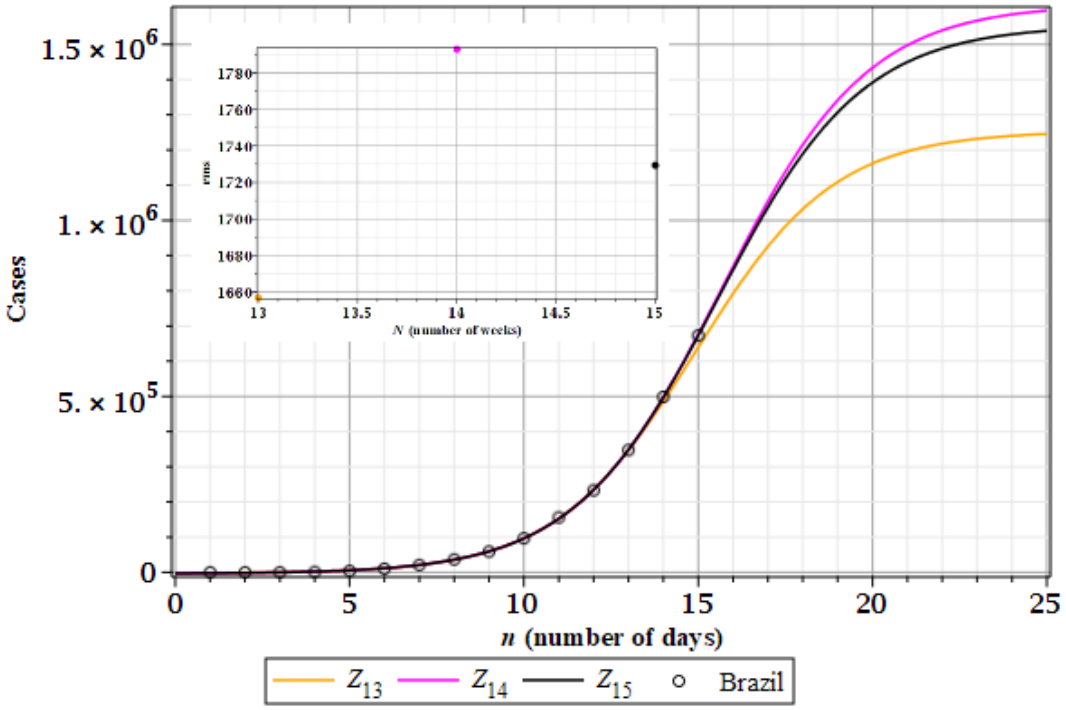


FIG. 67: Weekly Covid-19 case curves and rms for the data from Brazil.

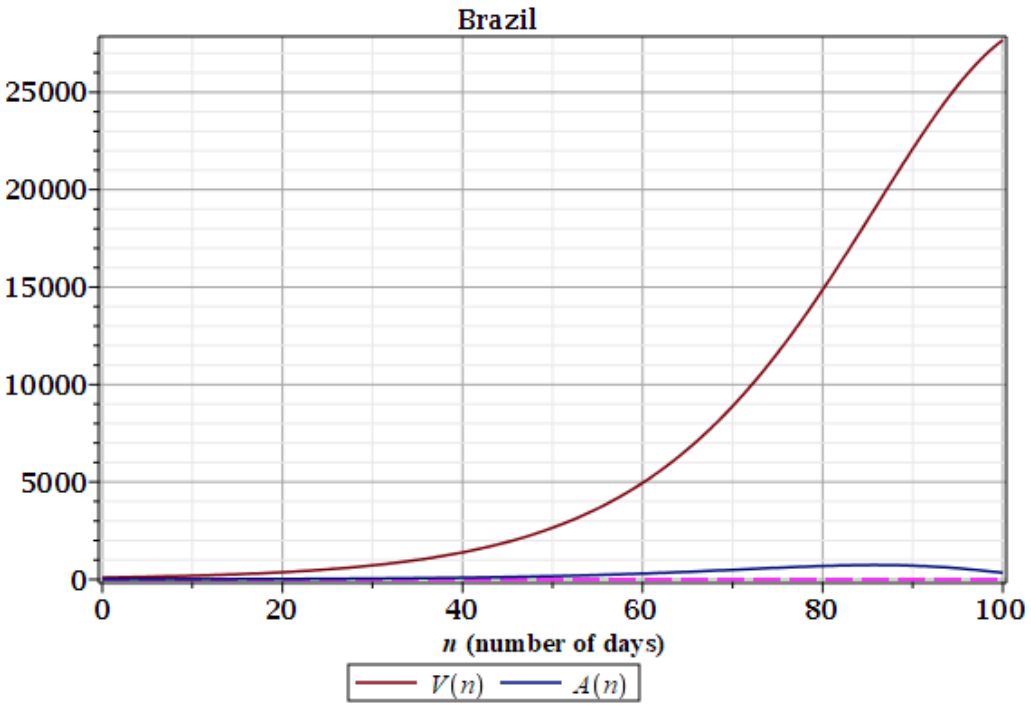


FIG. 68: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{100}. Incomplete curves. Case data behind the inflection point.

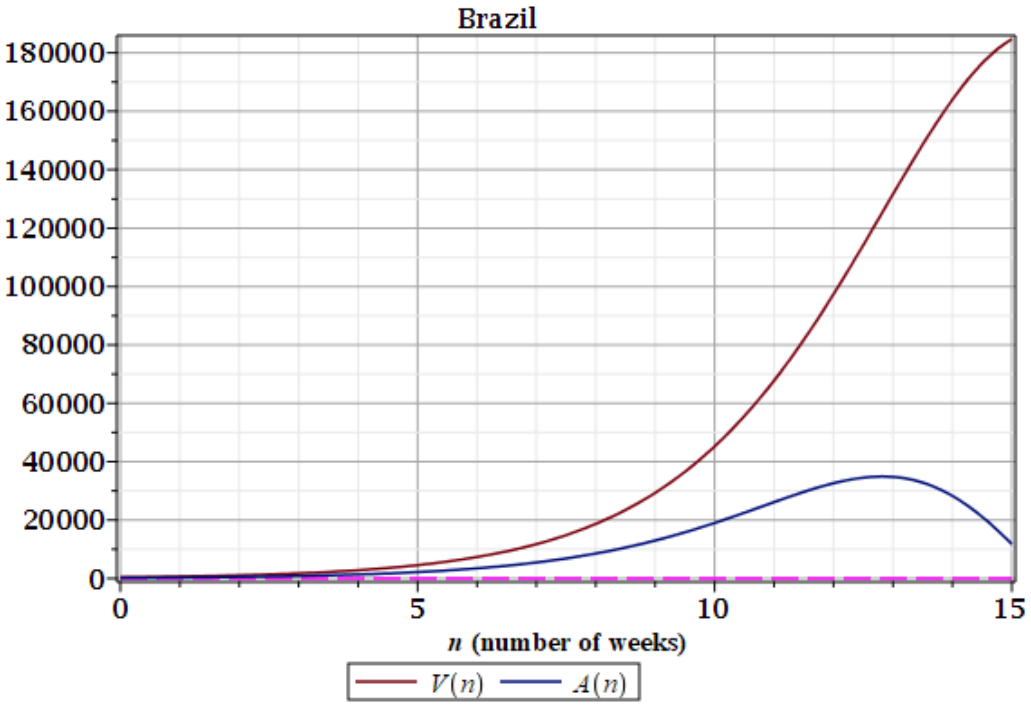


FIG. 69: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{15}. Incomplete curves. Case data behind the inflection point.

VI.18. India

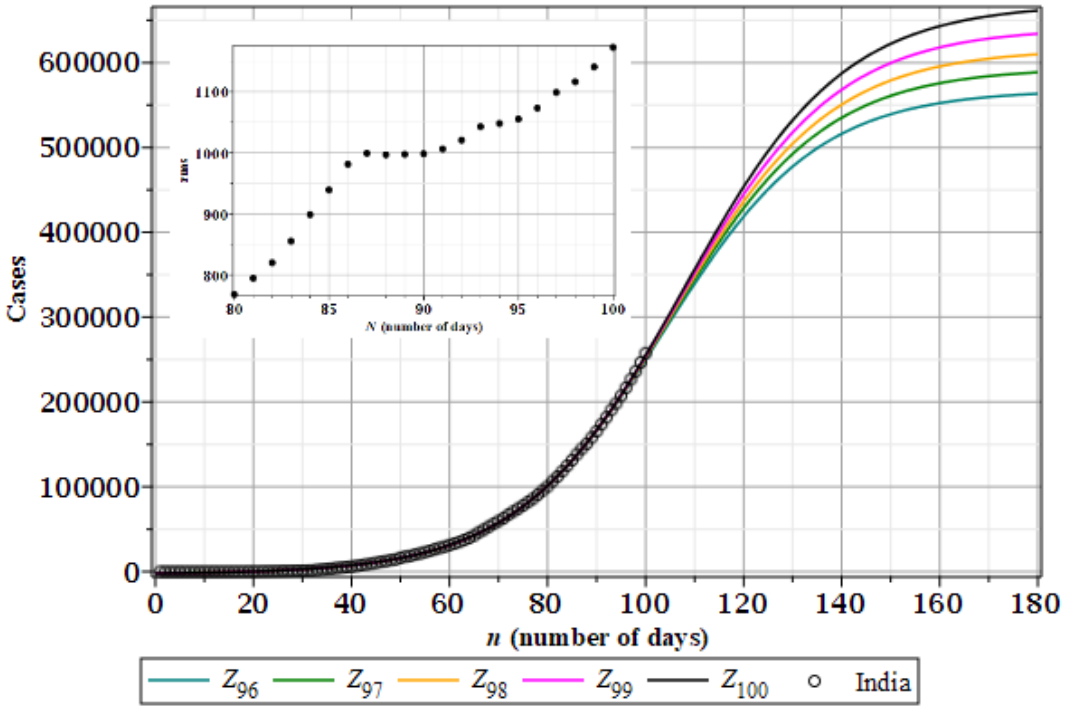


FIG. 70: Daily Covid-19 case curves and rms for the data from India.

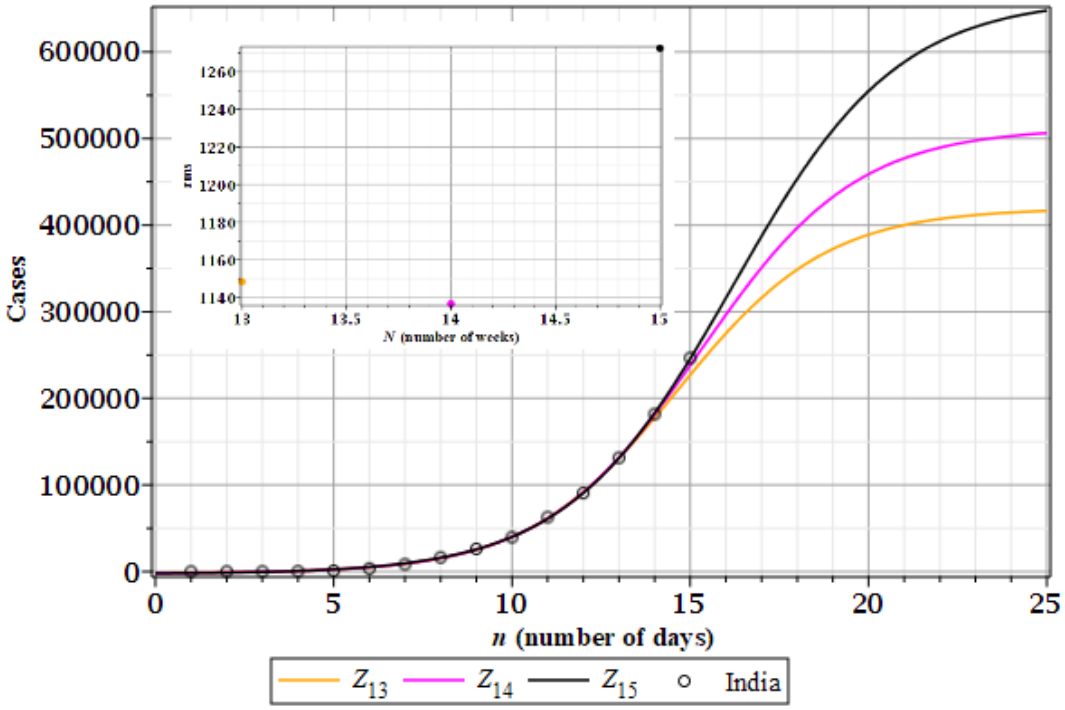


FIG. 71: Weekly Covid-19 case curves for the data from India.

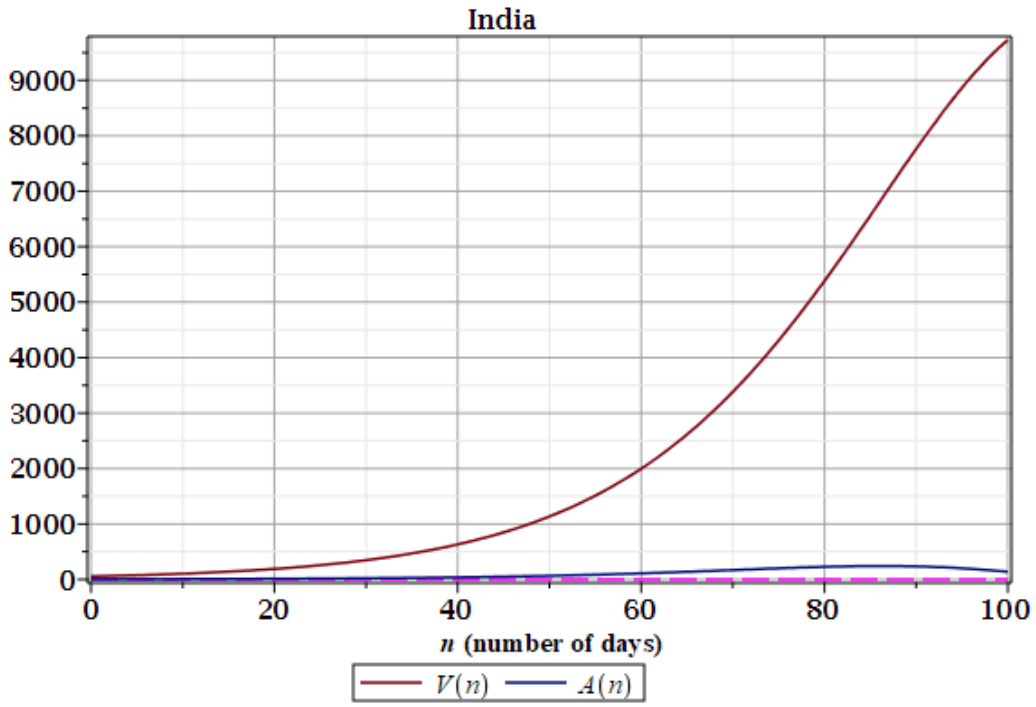


FIG. 72: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{100}. Incomplete curves. Case data behind the inflection point.

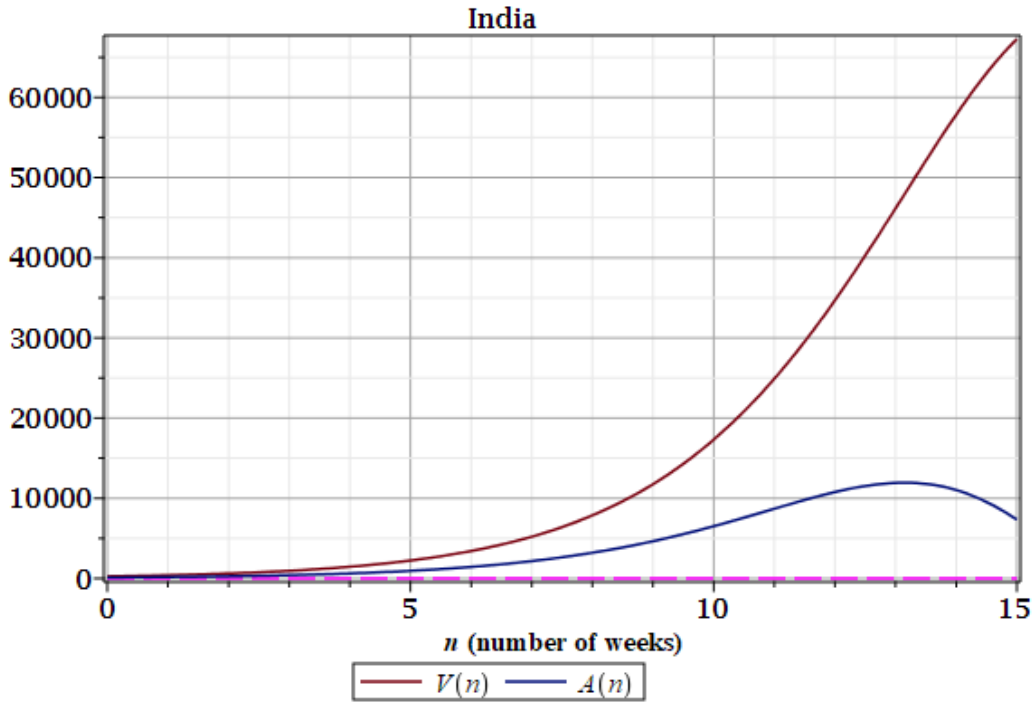


FIG. 73: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{15}. Incomplete curves. Case data behind the inflection point.

VI.19. Chile

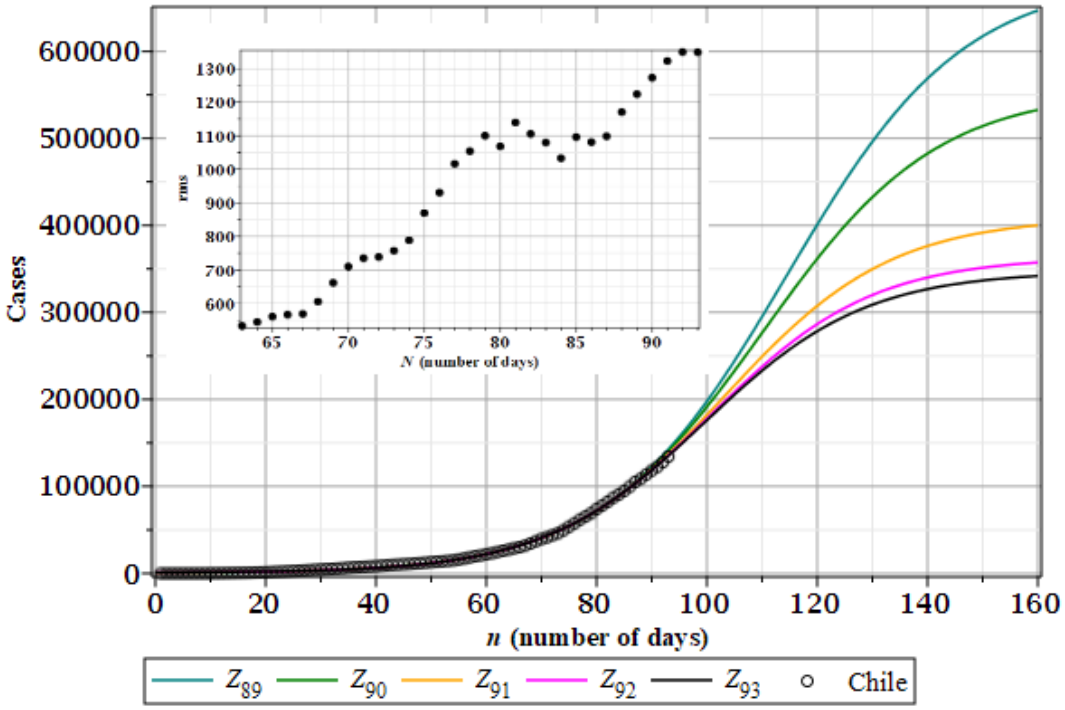


FIG. 74: Daily Covid-19 case curves and rms for the data from Chile.

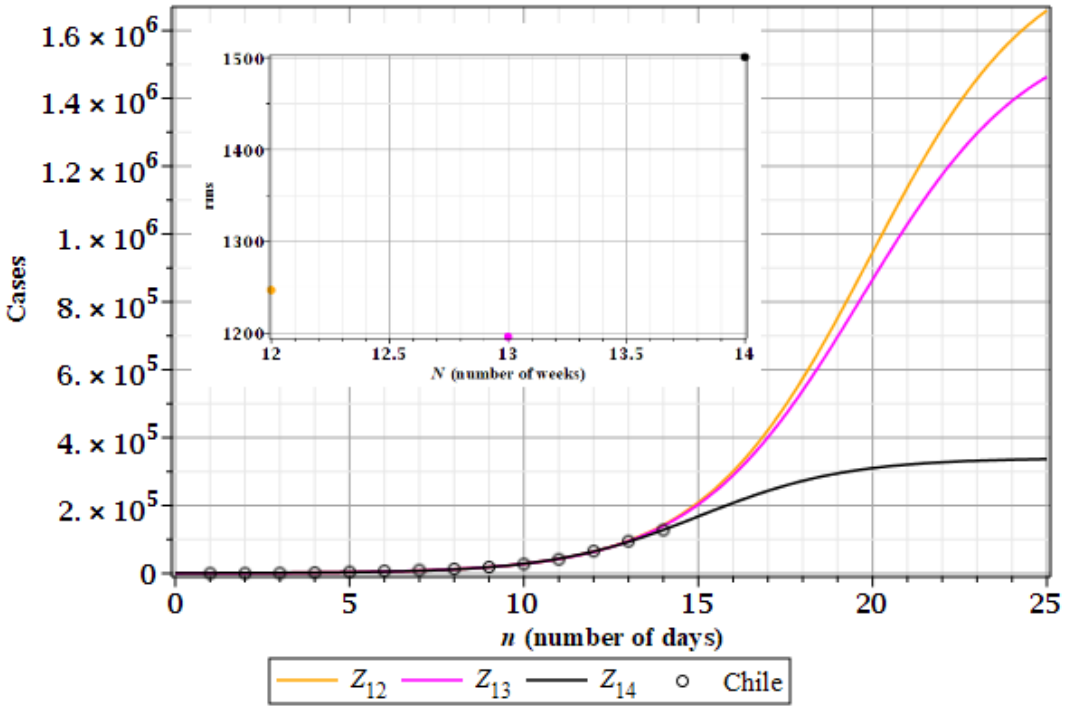


FIG. 75: Weekly Covid-19 case curves and rms for the data from Chile.

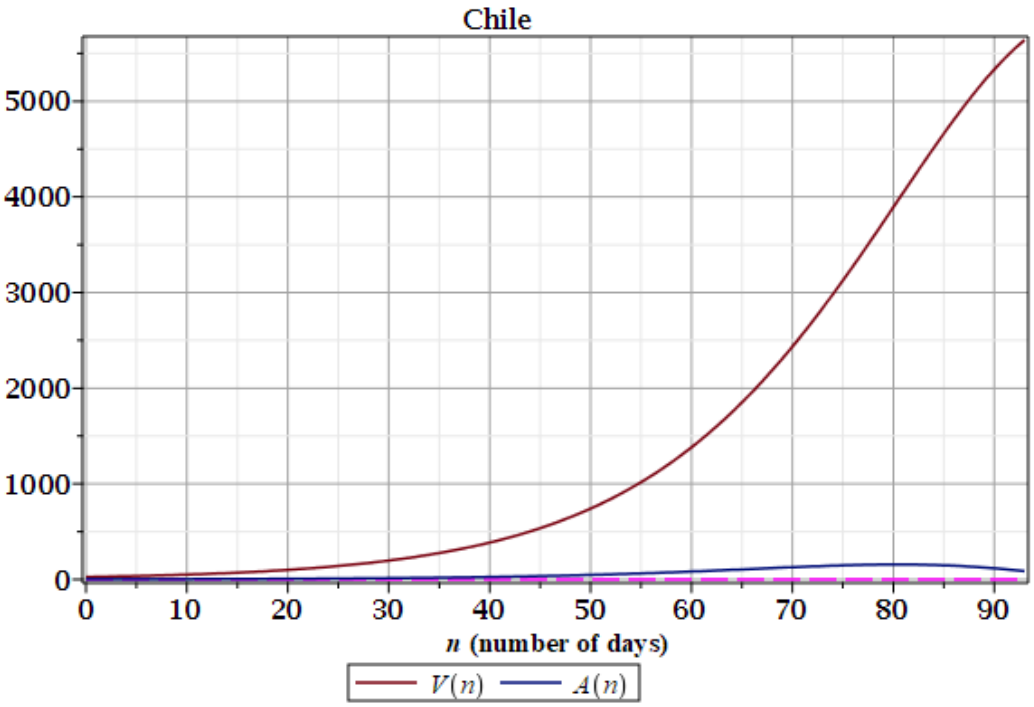


FIG. 76: Daily growth rates (speed V and acceleration A) from the fitted curve Z_{93}. Incomplete curves. Case data behind the inflection point.

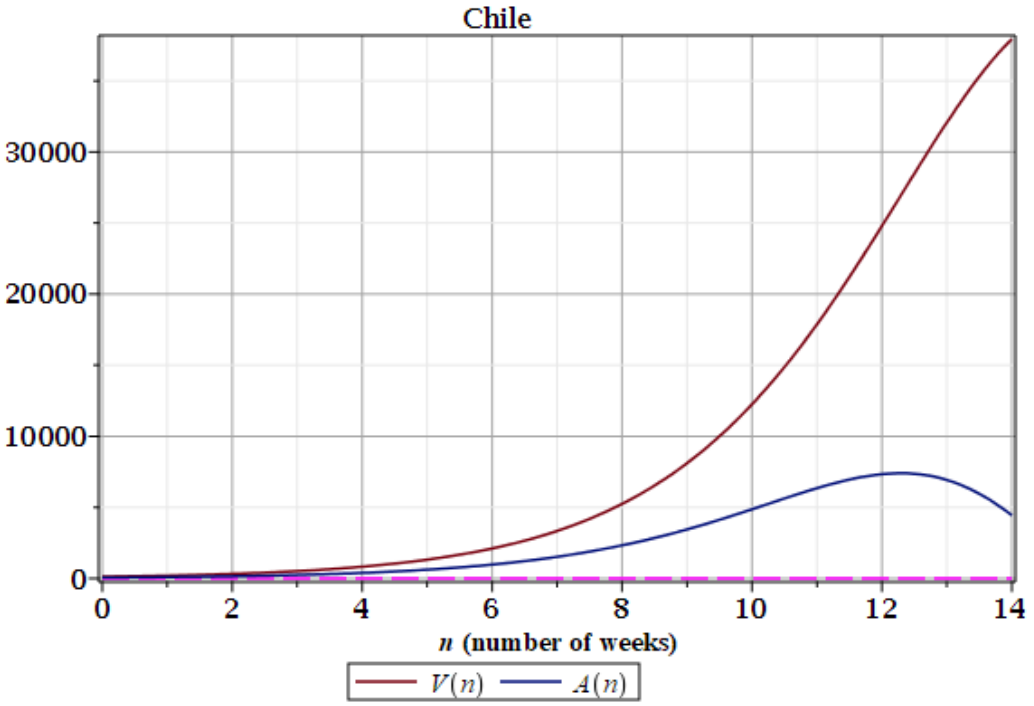


FIG. 77: Weekly growth rates (speed V and acceleration A) from the fitted curve Z_{14}. Incomplete curves. Case data behind the inflection point.

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