

COVID in Moscow

```
knitr::opts_chunk$set(echo = FALSE, message=FALSE, warning=FALSE, fig.width=9, fig.height=6, fig.path = "figures/")
```

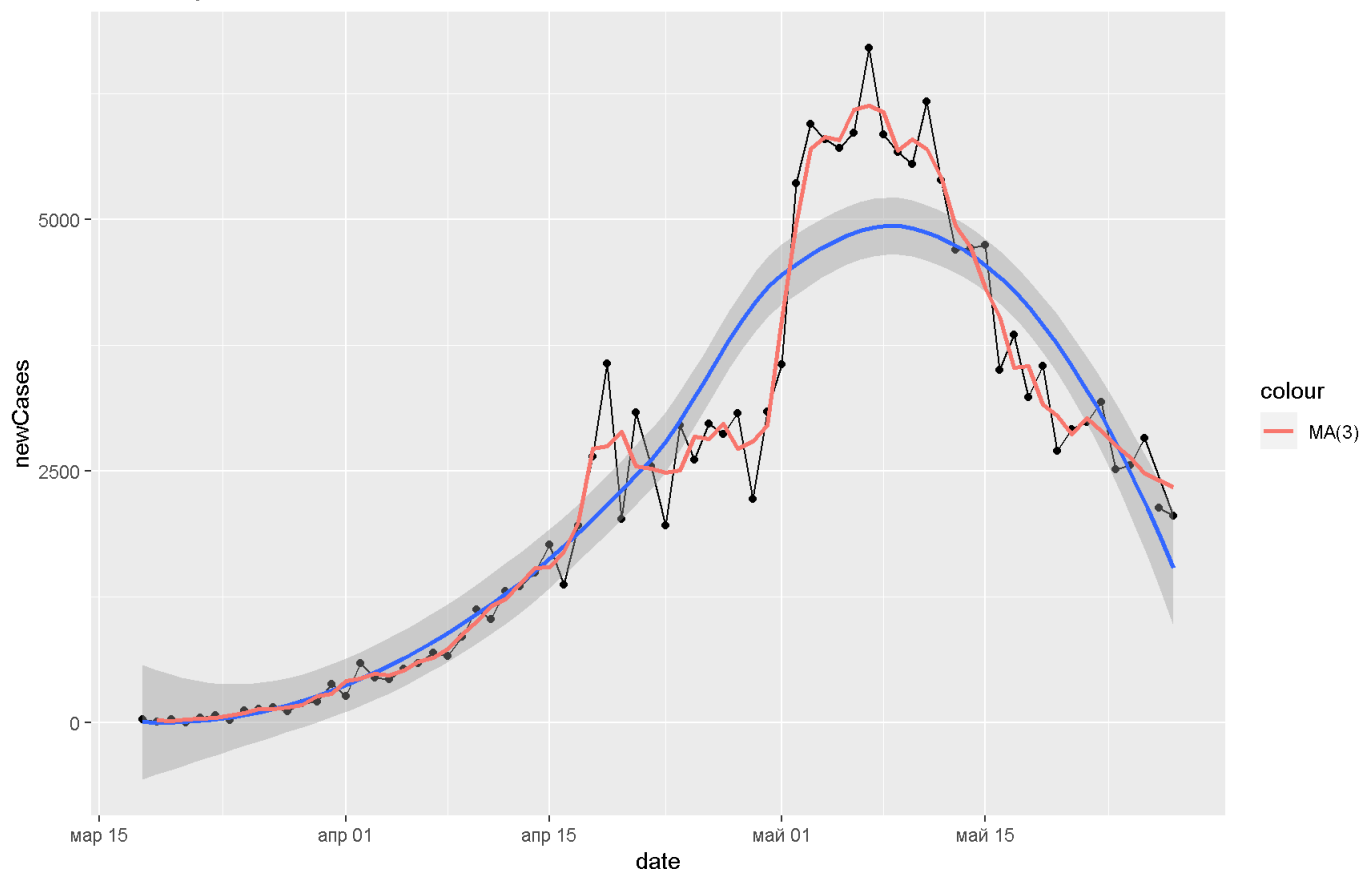
```
## [1] "CovidMoscowDB was NOT updated"
```

Общий тренд

New daily COVID cases in Moscow (log10 scale)



New daily COVID cases in Moscow



One line

```
##
## Call:
## lm(formula = log(newCases) ~ days_from_beg, data = CovidMoscow)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -3.1363 -0.6370  0.3773  0.7057  1.3465
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   4.73087    0.21762   21.74  <2e-16 ***
## days_from_beg  0.06572    0.00529   12.42  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9329 on 70 degrees of freedom
## Multiple R-squared:  0.6879, Adjusted R-squared:  0.6835
## F-statistic: 154.3 on 1 and 70 DF,  p-value: < 2.2e-16
```

Segmented

```
##
## ----- N. Breaking points = 1 -----
##
## ***Regression Model with Segmented Relationship(s)***
##
## Call:
## segmented.lm(obj = lm_msk0, psi = start_psi[1:npt])
##
## Estimated Break-Point(s):
##              Est. St.Err
## psi1.days_from_beg 31.311  1.306
##
## Meaningful coefficients of the linear terms:
##              Estimate Std. Error t value Pr(>|t|)
```

```

## (Intercept)      3.192574    0.152308    20.96    <2e-16 ***
## days_from_beg    0.159579    0.008442    18.90    <2e-16 ***
## U1.days_from_beg -0.159935    0.010380   -15.41      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4409 on 68 degrees of freedom
## Multiple R-Squared: 0.9323, Adjusted R-squared: 0.9293
##
## Convergence attained in 2 iter. (rel. change 2.6671e-16)
##
## ----- N. Breaking points = 2 -----
##
## ***Regression Model with Segmented Relationship(s)***
##
## Call:
## segmented.lm(obj = lm_msk0, psi = start_psi[1:npt])
##
## Estimated Break-Point(s):
##              Est. St.Err
## psi1.days_from_beg 15.408  1.219
## psi2.days_from_beg 49.640  1.407
##
## Meaningful coefficients of the linear terms:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.65796    0.15661   16.97    <2e-16 ***
## days_from_beg     0.23609    0.01779   13.27    <2e-16 ***
## U1.days_from_beg -0.16261    0.01869   -8.70      NA
## U2.days_from_beg -0.12722    0.01243  -10.24      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.328 on 66 degrees of freedom
## Multiple R-Squared: 0.9636, Adjusted R-squared: 0.9609
##
## Convergence attained in 2 iter. (rel. change 1.7055e-06)
##
## ----- N. Breaking points = 3 -----
##
## ***Regression Model with Segmented Relationship(s)***
##
## Call:
## segmented.lm(obj = lm_msk0, psi = start_psi[1:npt])
##
## Estimated Break-Point(s):
##              Est. St.Err
## psi1.days_from_beg 13.000  1.904
## psi2.days_from_beg 28.003  3.616
## psi3.days_from_beg 51.253  1.778
##
## Meaningful coefficients of the linear terms:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64540    0.16713   15.829 < 2e-16 ***
## days_from_beg     0.23923    0.02364   10.122 6.53e-15 ***
## U1.days_from_beg -0.12692    0.02929   -4.334      NA
## U2.days_from_beg -0.05672    0.01999   -2.838      NA
## U3.days_from_beg -0.11002    0.01592   -6.912      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3189 on 64 degrees of freedom
## Multiple R-Squared: 0.9667, Adjusted R-squared: 0.963
##
## Convergence attained in 10 iter. (rel. change 7.7821e-08)
##
## ----- N. Breaking points = 4 -----
##
## ***Regression Model with Segmented Relationship(s)***
##
## Call:
## segmented.lm(obj = lm_msk0, psi = start_psi[1:npt])
##
## Estimated Break-Point(s):

```

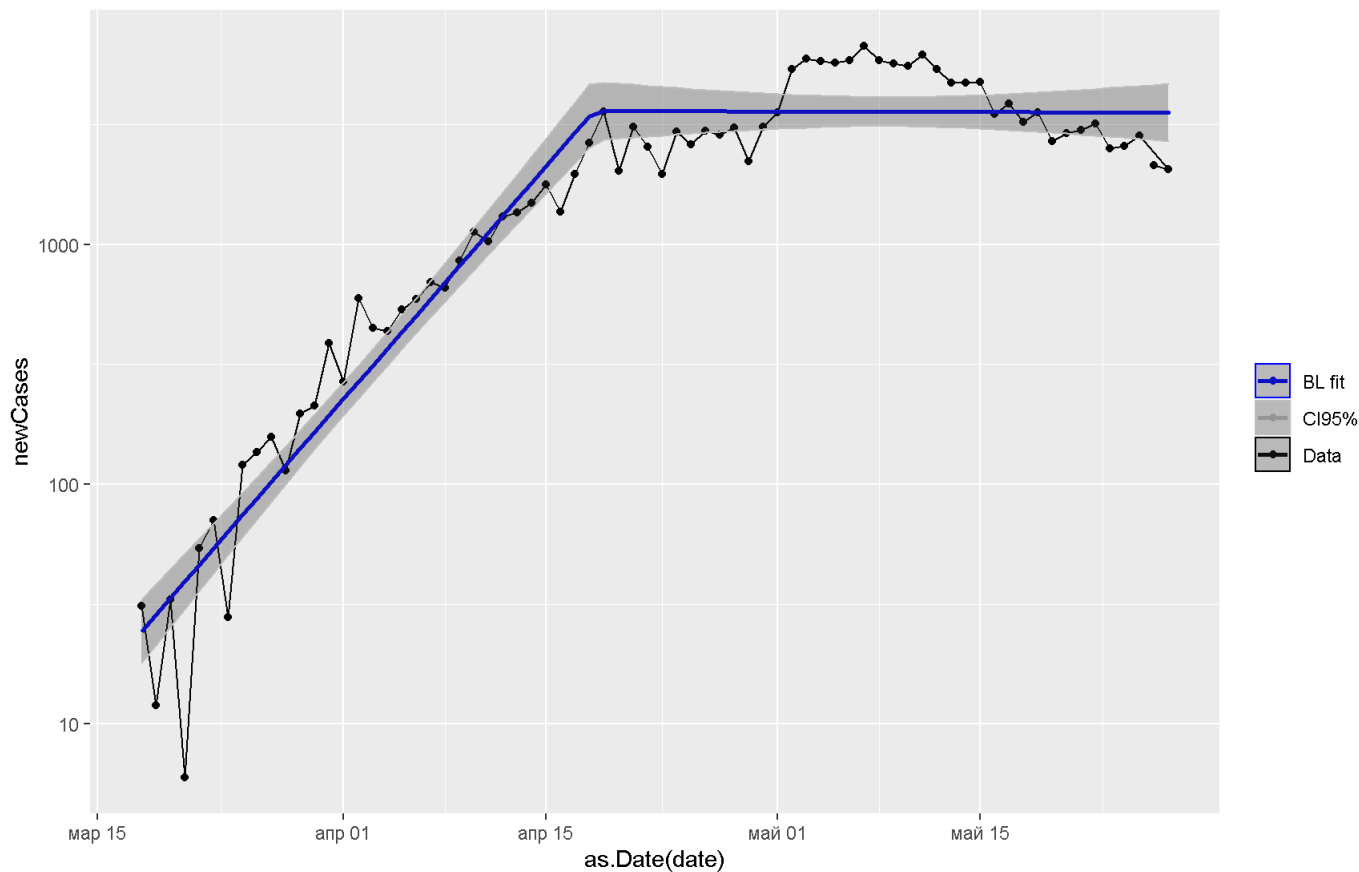
```

## Summary Break Point(s):
##               Est. St.Err
## psi1.days_from_beg 13.000  1.788
## psi2.days_from_beg 30.000  3.126
## psi3.days_from_beg 45.001  3.014
## psi4.days_from_beg 48.000  1.245
##
## Meaningful coefficients of the linear terms:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64435    0.16194  16.329 <2e-16 ***
## days_from_beg     0.23950    0.02117  11.311 <2e-16 ***
## U1.days_from_beg -0.12813    0.02642   -4.849    NA
## U2.days_from_beg -0.07303    0.02478   -2.947    NA
## U3.days_from_beg  0.16998    0.22662    0.750    NA
## U4.days_from_beg -0.25904    0.22604   -1.146    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3194 on 62 degrees of freedom
## Multiple R-Squared:  0.9676, Adjusted R-squared:  0.9629
##
## Convergence attained in 1 iter. (rel. change -2.94e-06)
##
## ----- N. Breaking points = 5 -----
##
## ***Regression Model with Segmented Relationship(s)***
##
## Call:
## segmented.lm(obj = lm_msk0, psi = start_psi[1:npt])
##
## Estimated Break-Point(s):
##               Est. St.Err
## psi1.days_from_beg 13.000  1.720
## psi2.days_from_beg 31.998  2.152
## psi3.days_from_beg 42.622  1.502
## psi4.days_from_beg 45.464  1.742
## psi5.days_from_beg 51.370  4.402
##
## Meaningful coefficients of the linear terms:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64470    0.15840  16.696 <2e-16 ***
## days_from_beg     0.23941    0.02071  11.560 <2e-16 ***
## U1.days_from_beg -0.12831    0.02511   -5.111    NA
## U2.days_from_beg -0.10861    0.03299   -3.292    NA
## U3.days_from_beg  0.26804    0.22288    1.203    NA
## U4.days_from_beg -0.25980    0.23316   -1.114    NA
## U5.days_from_beg -0.06510    0.07565   -0.861    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3124 on 60 degrees of freedom
## Multiple R-Squared:  0.97, Adjusted R-squared:  0.9645
##
## Convergence attained in 13 iter. (rel. change 5.0844e-07)
## breakpoint estimate(s): 0.4723582 11.56513 17.68183 33.42125 40.15426 49.20468
##
## ----- N. Breaking points = 6 -----
##
## ***Regression Model with Segmented Relationship(s)***
##
## Call:
## segmented.lm(obj = lm_msk0, psi = start_psi[1:npt])
##
## Estimated Break-Point(s):
##               Est. St.Err
## psi1.days_from_beg 13.004  1.719
## psi2.days_from_beg 31.997  2.382
## psi3.days_from_beg 42.678  1.481
## psi4.days_from_beg 45.543  1.623
## psi5.days_from_beg 53.945  4.279
## psi6.days_from_beg 60.894  8.857
##
## Meaningful coefficients of the linear terms:
##

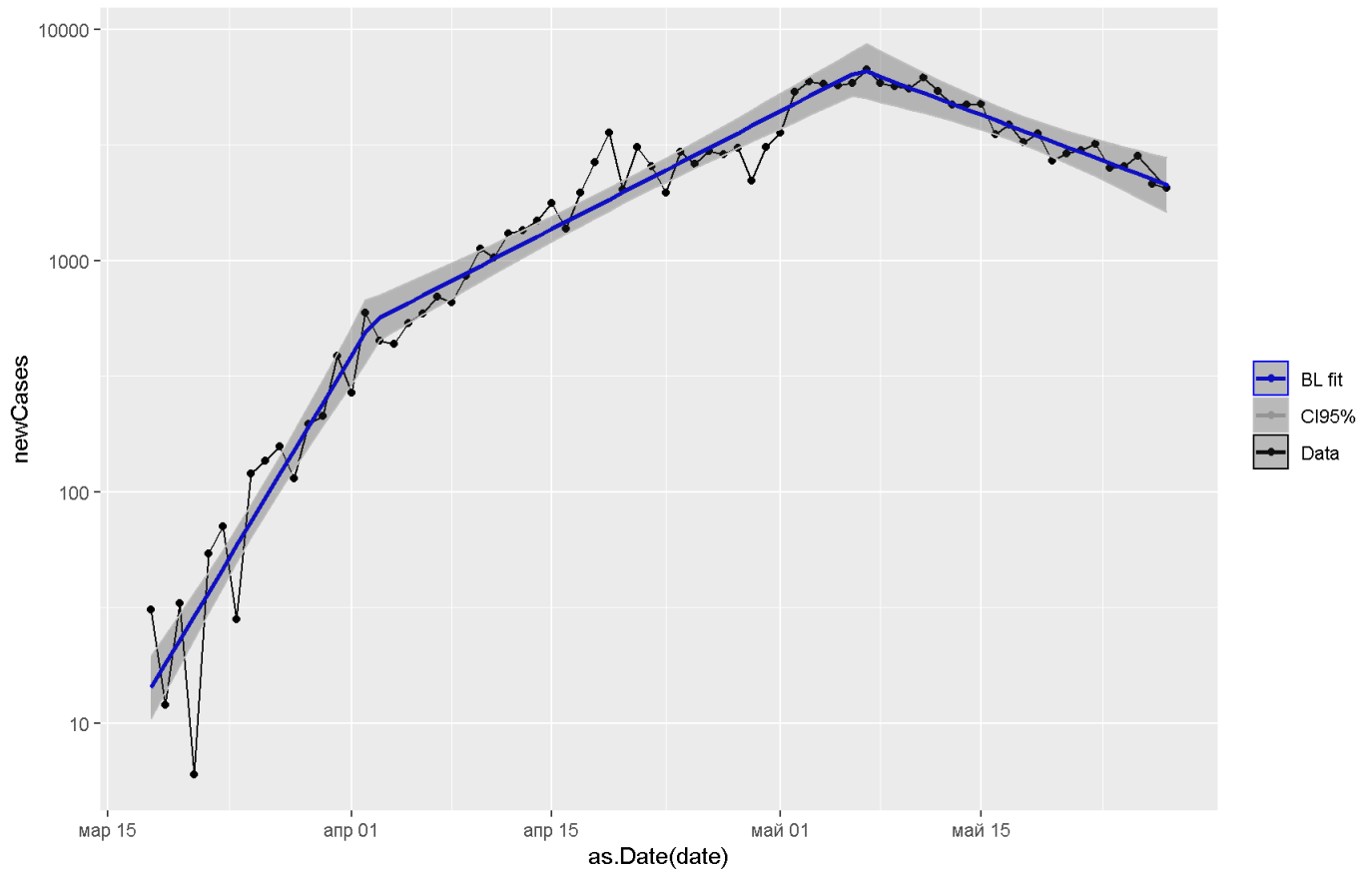
```

```
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64474    0.16059  16.468  <2e-16 ***
## days_from_beg    0.23940    0.02100  11.402  <2e-16 ***
## U1.days_from_beg -0.12836    0.02484   -5.168    NA
## U2.days_from_beg -0.10815    0.03731   -2.899    NA
## U3.days_from_beg  0.27330    0.22664    1.206    NA
## U4.days_from_beg -0.27755    0.22921   -1.211    NA
## U5.days_from_beg -0.07661    0.07727   -0.992    NA
## U6.days_from_beg  0.03598    0.06704    0.537    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3167 on 58 degrees of freedom
## Multiple R-Squared:  0.9702, Adjusted R-squared:  0.9635
##
## Convergence attained in 5 iter. (rel. change 4.441e-06)
```

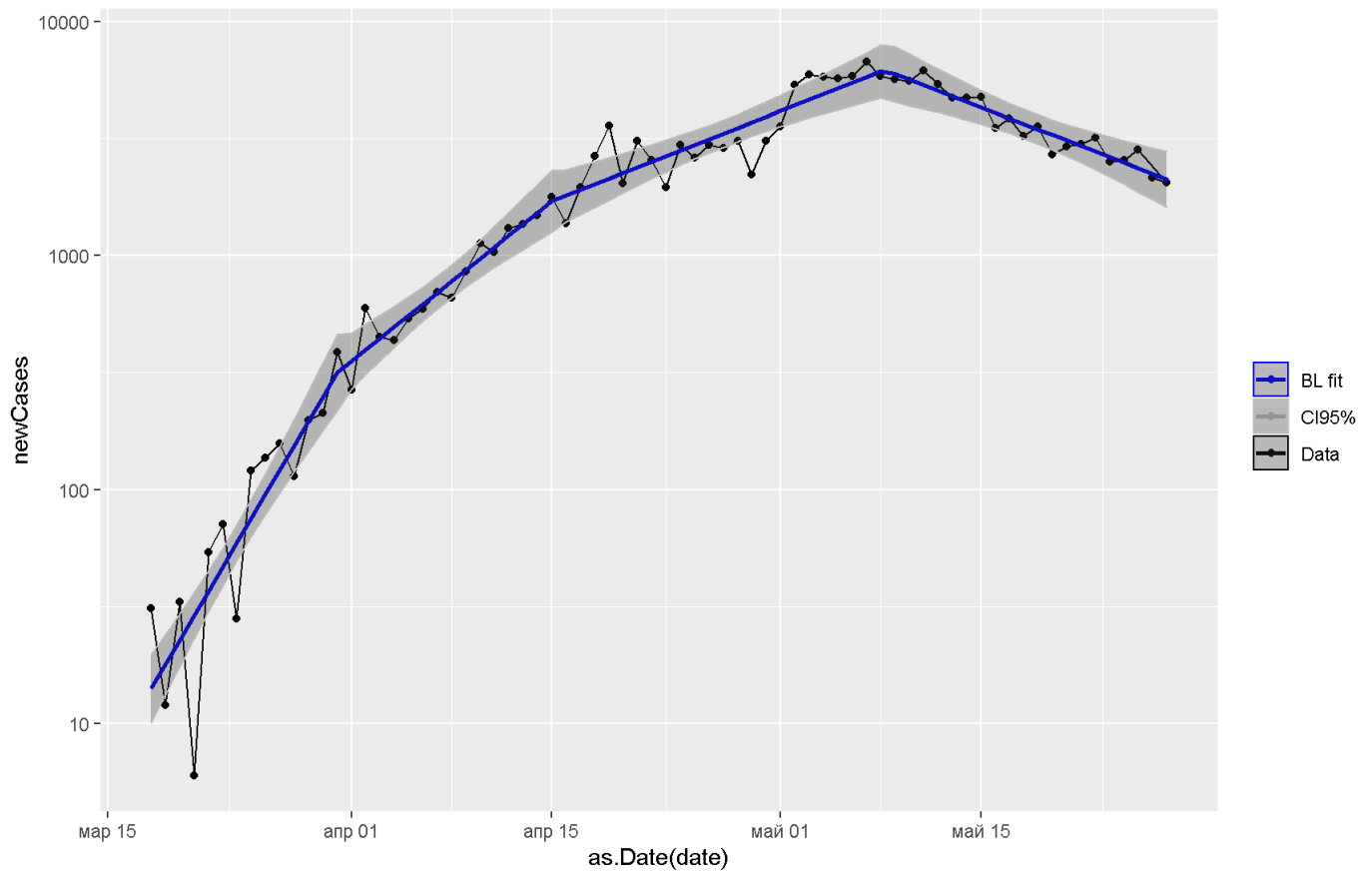
New daily COVID cases in Moscow (npsi=1)



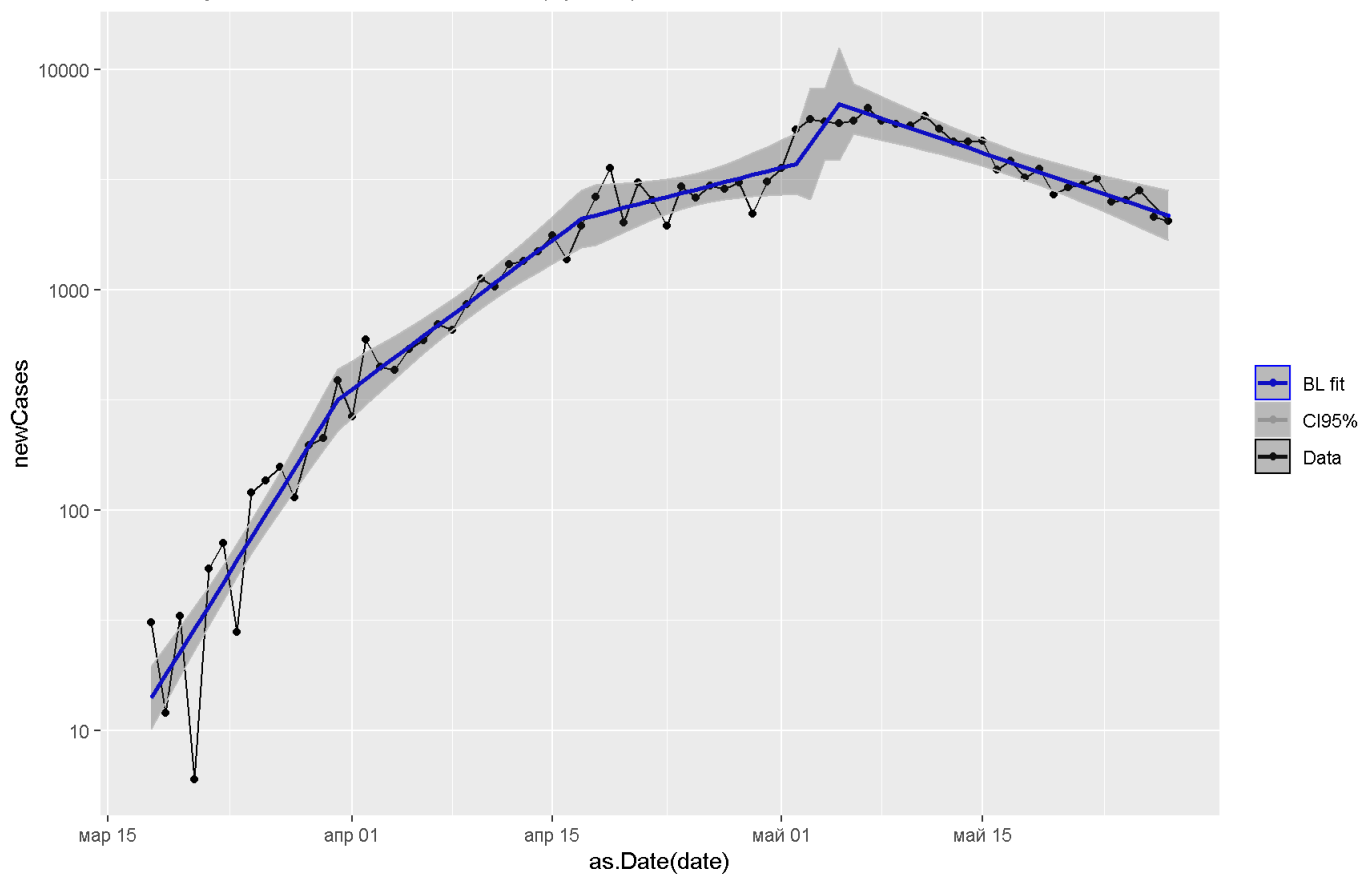
New daily COVID cases in Moscow (npsi=2)



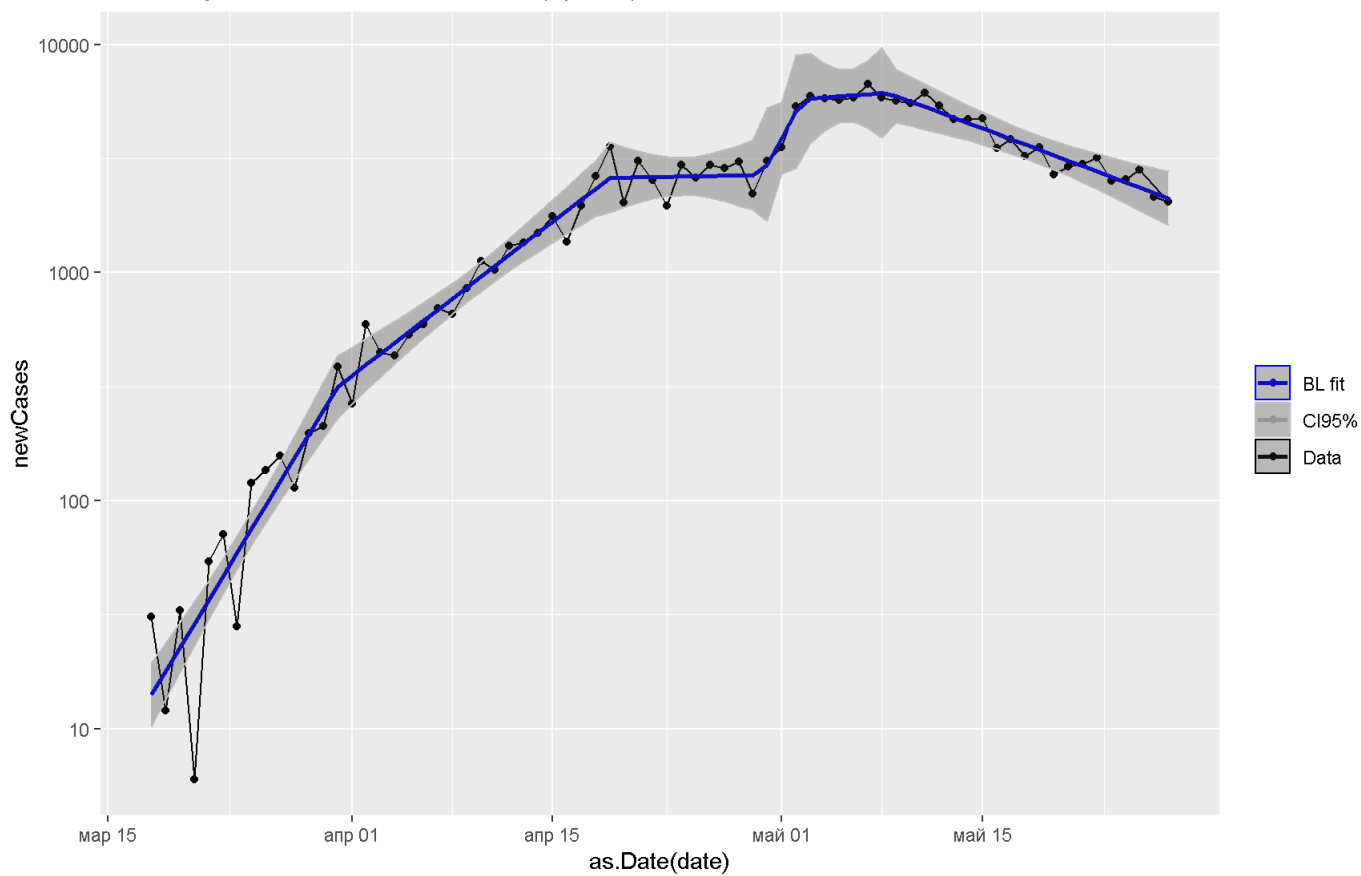
New daily COVID cases in Moscow (npsi=3)



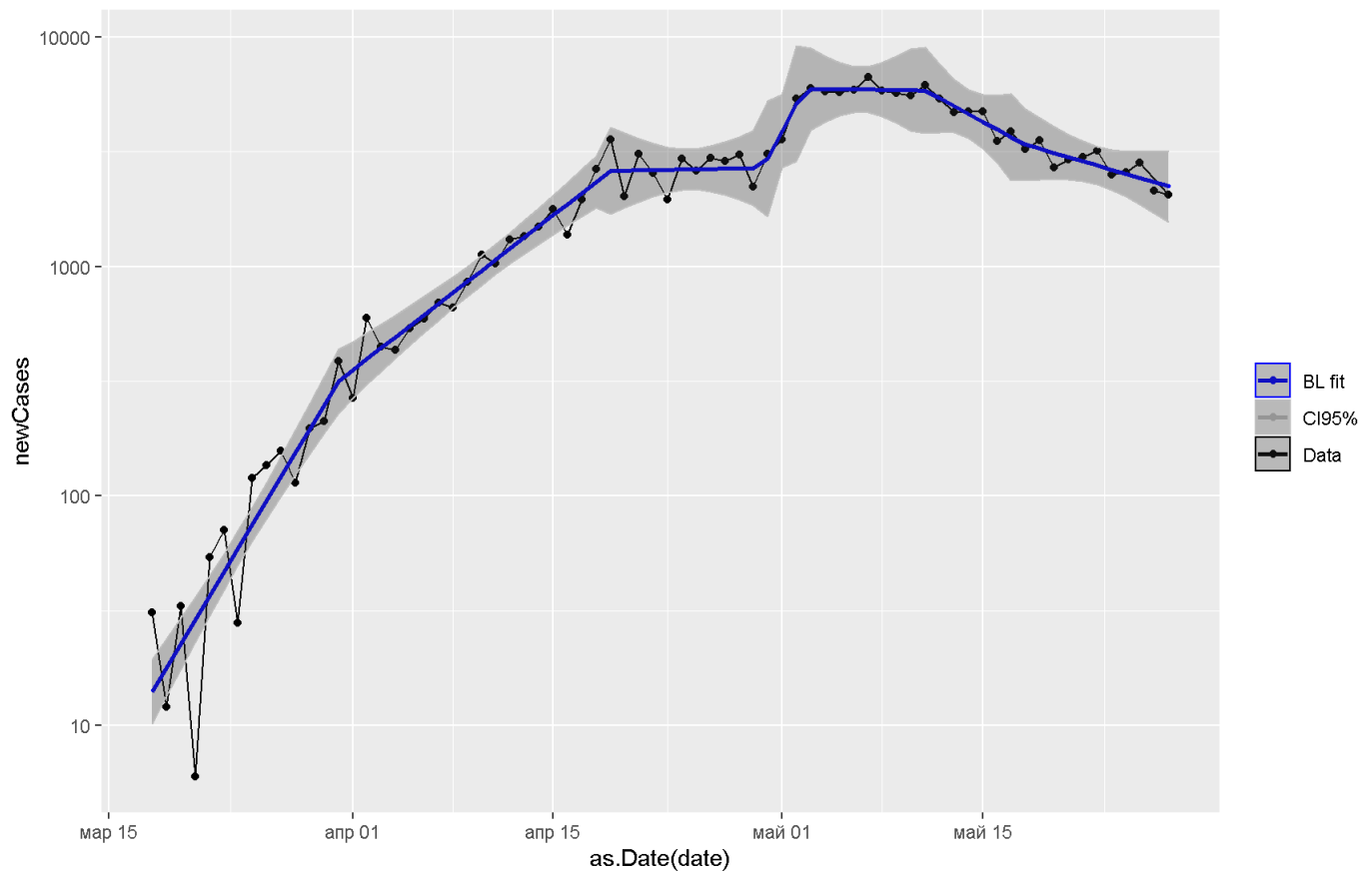
New daily COVID cases in Moscow (npsi=4)



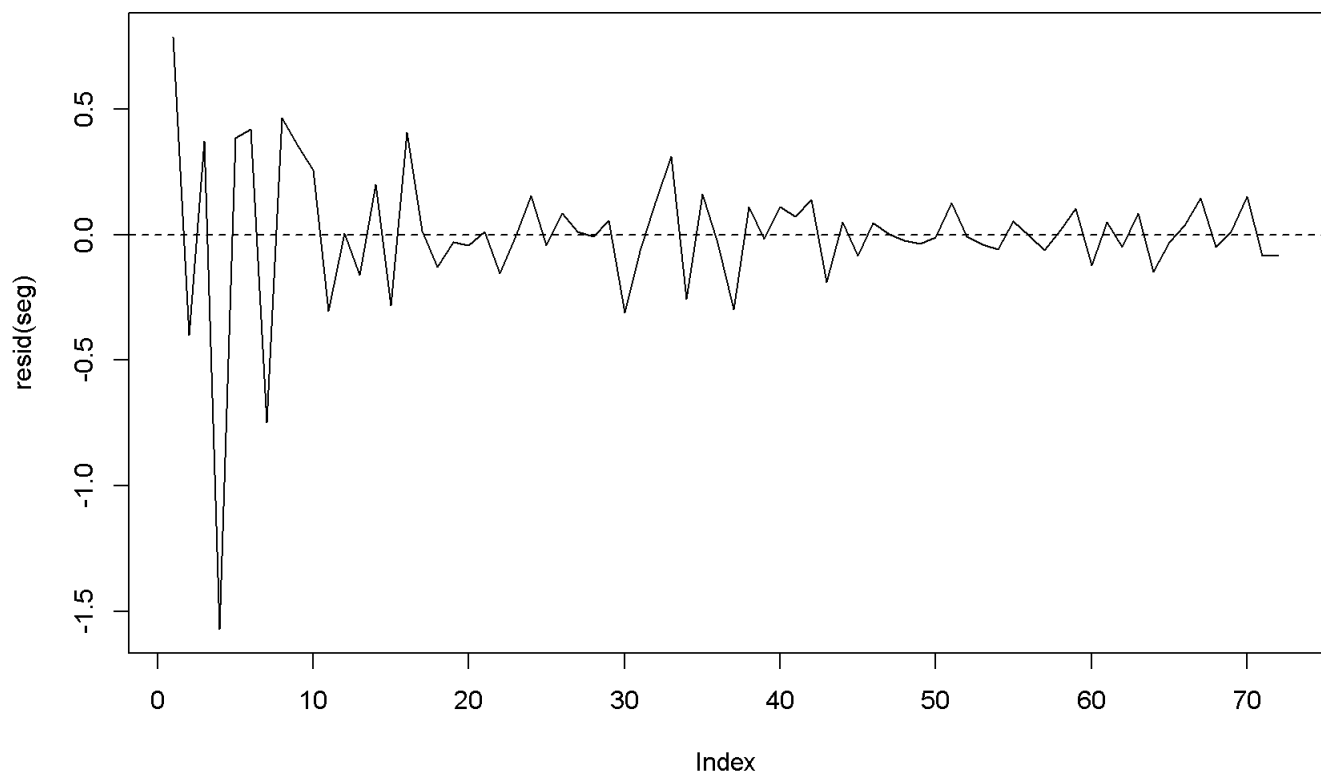
New daily COVID cases in Moscow (npsi=5)



New daily COVID cases in Moscow (npsi=6)



Seg log(newCases) residuals (npsi=6)



```
##
## ----- N. Breaking points = 1 -----
## Slopes
## $days_from_beg
##           Est.   St.Err.   t value CI(95%).l CI(95%).u
## slope1  0.15958000 0.0084420 18.903000  0.142730  0.176430
## slope2 -0.00035581 0.0060396 -0.058913 -0.012408  0.011696
```



```

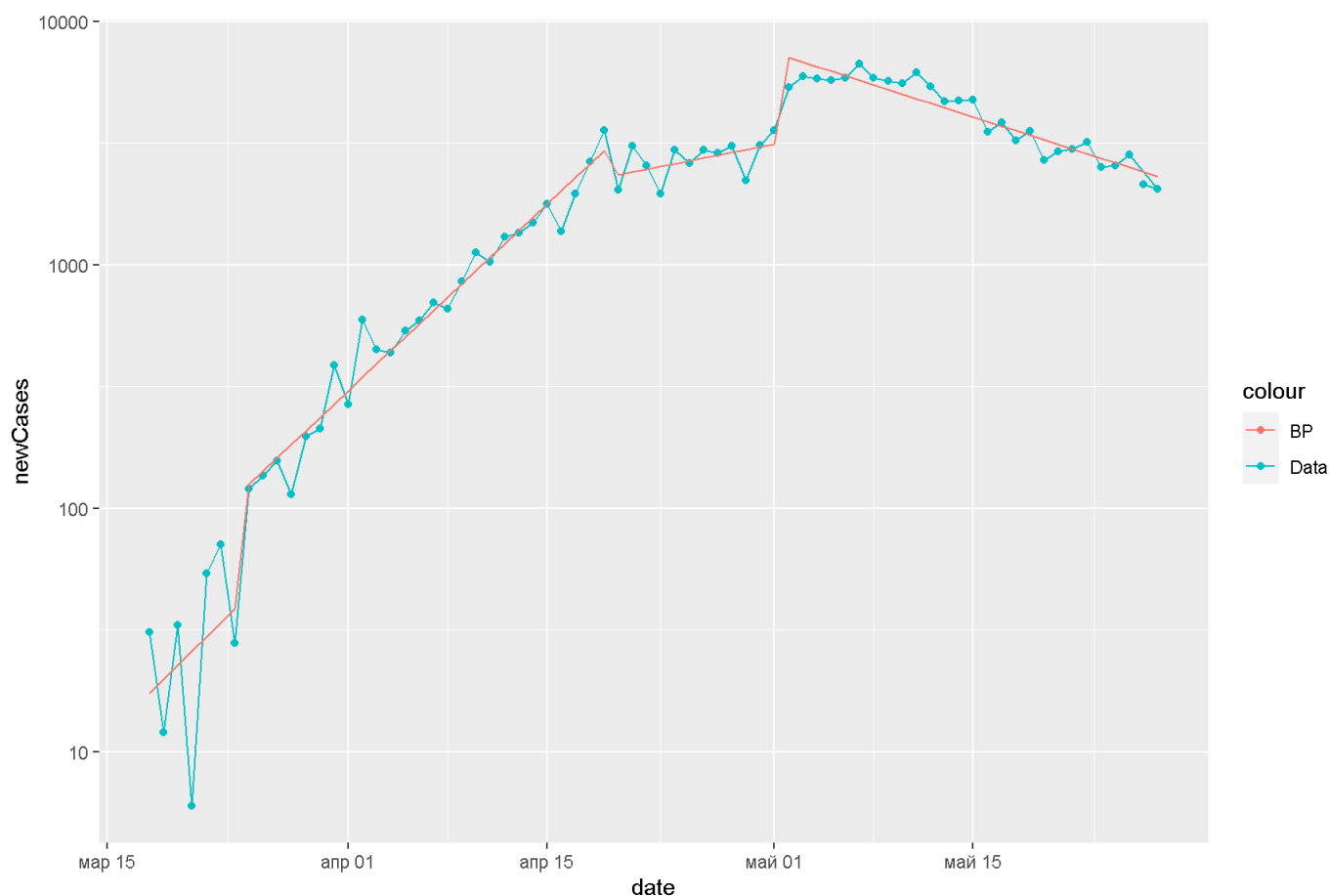
##
## Doubling of cases:
##      slope1      slope2
##      4.343572 -1948.082349
##
## ----- N. Breaking points = 2 -----
## Slopes
## $days_from_beg
##      Est.   St.Err. t value CI(95%).l CI(95%).u
## slope1  0.236090 0.0177900 13.2710  0.200570  0.271600
## slope2  0.073471 0.0057342 12.8130  0.062022  0.084919
## slope3 -0.053751 0.0110230 -4.8761 -0.075760 -0.031742
##
## Doubling of cases:
##      slope1      slope2      slope3
##      2.935945   9.434296 -12.895522
##
## ----- N. Breaking points = 3 -----
## Slopes
## $days_from_beg
##      Est.   St.Err. t value CI(95%).l CI(95%).u
## slope1  0.239230 0.023635 10.1220  0.192020  0.286450
## slope2  0.112320 0.017292  6.4950  0.077770  0.146860
## slope3  0.055593 0.010023  5.5465  0.035570  0.075617
## slope4 -0.054423 0.012365 -4.4015 -0.079124 -0.029721
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4
##      2.897409   6.171182  12.468246 -12.736291
##
## ----- N. Breaking points = 4 -----
## Slopes
## $days_from_beg
##      Est.   St.Err. t value  CI(95%).l CI(95%).u
## slope1  0.239500 0.021173 11.31100  0.19717000  0.281820
## slope2  0.111360 0.015810  7.04360  0.07975600  0.142970
## slope3  0.038332 0.019085  2.00850  0.00018156  0.076482
## slope4  0.208310 0.225820  0.92248 -0.24309000  0.659710
## slope5 -0.050727 0.010039 -5.05320 -0.07079500 -0.030660
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5
##      2.894143   6.224382  18.082729   3.327479 -13.664265
##
## ----- N. Breaking points = 5 -----
## Slopes
## $days_from_beg
##      Est.   St.Err. t value CI(95%).l CI(95%).u
## slope1  0.2394100 0.020710 11.560000  0.197980  0.280830
## slope2  0.1111000 0.014191  7.828500  0.082710  0.139480
## slope3  0.0024823 0.029783  0.083347 -0.057093  0.062058
## slope4  0.2705200 0.220880  1.224700 -0.171300  0.712350
## slope5  0.0107170 0.074671  0.143530 -0.138650  0.160080
## slope6 -0.0543810 0.012113 -4.489400 -0.078611 -0.030150
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5      slope6
##      2.895231   6.238949 279.235862  2.562277  64.677352 -12.746128
##
## ----- N. Breaking points = 6 -----
## Slopes
## $days_from_beg
##      Est.   St.Err. t value CI(95%).l CI(95%).u
## slope1  0.2394000 0.020997 11.402000  0.197370  0.281430
## slope2  0.1110400 0.013266  8.370300  0.084482  0.137590
## slope3  0.0028818 0.034867  0.082652 -0.066913  0.072676
## slope4  0.2761800 0.223940  1.233300 -0.172080  0.724450
## slope5 -0.0013717 0.048867 -0.028069 -0.099191  0.096447
## slope6 -0.0779840 0.059850 -1.303000 -0.197790  0.041820
## slope7 -0.0420070 0.030196 -1.391200 -0.102450  0.018436
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5      slope6

```

```
##      slope1      slope2      slope3      slope4      slope5      slope6      slope7
## 2.895352  6.242320 240.525776  2.509766 -505.319808 -8.888326
##      slope7
## -16.500754
```

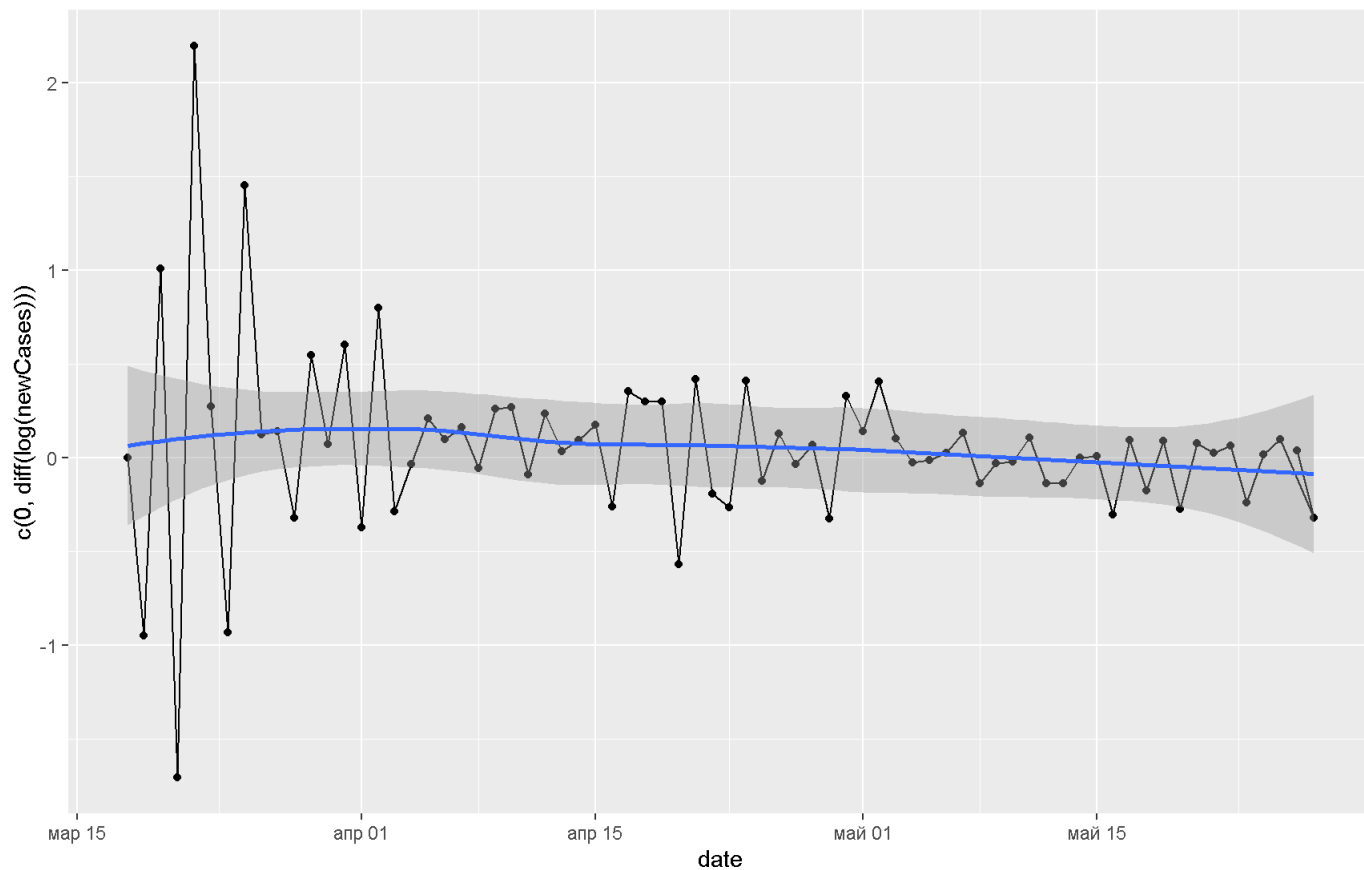
Struct change

```
##
## Optimal 4-segment partition:
##
## Call:
## breakpoints.formula(formula = log(newCases) ~ days_from_beg,
##   h = 7/CovidMoscow[, .N], data = CovidMoscow)
##
## Breakpoints at observation number:
## 7 33 45
##
## Corresponding to breakdates:
## 0.09722222 0.4583333 0.625
```

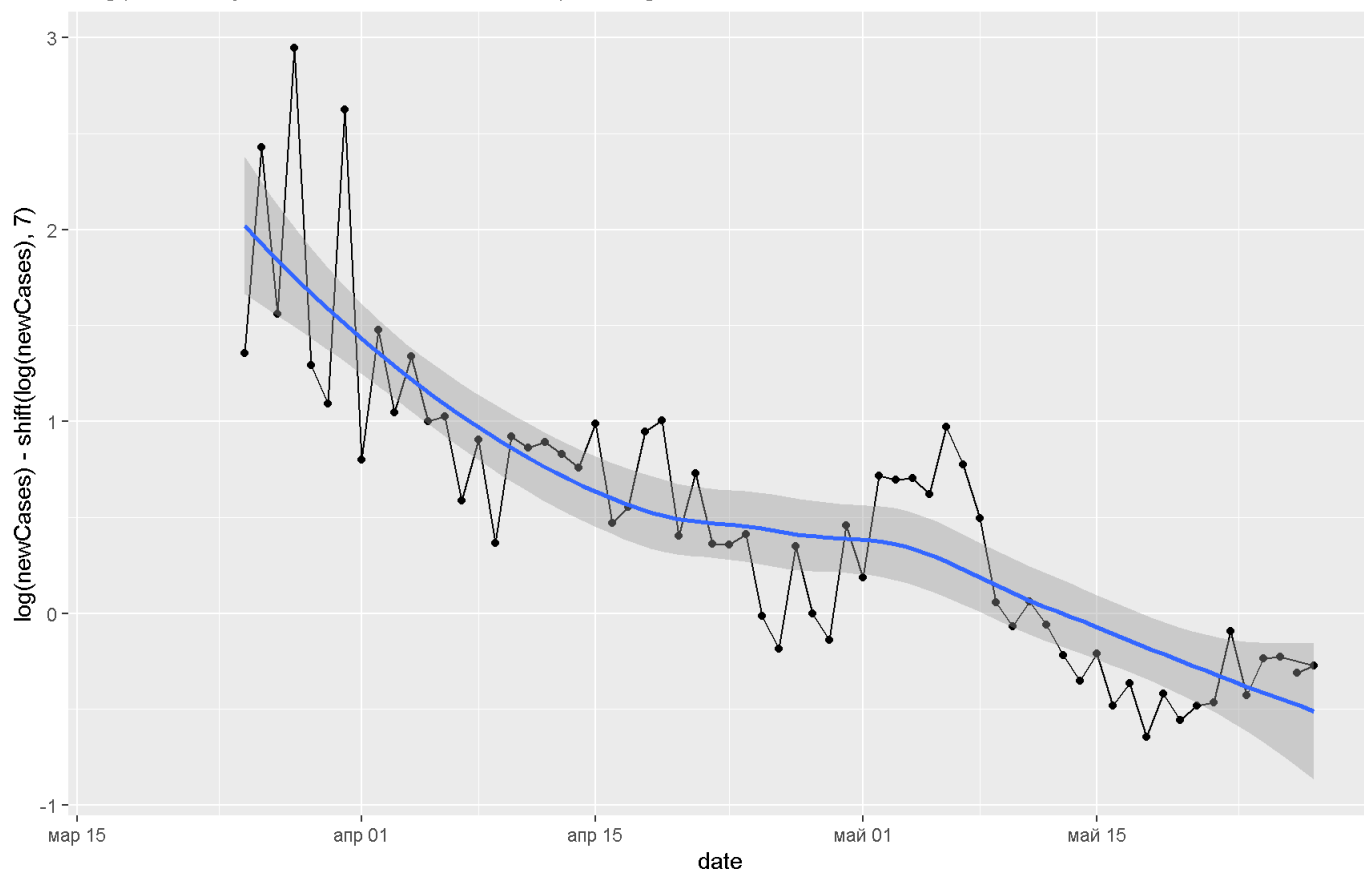


Дифференциалы

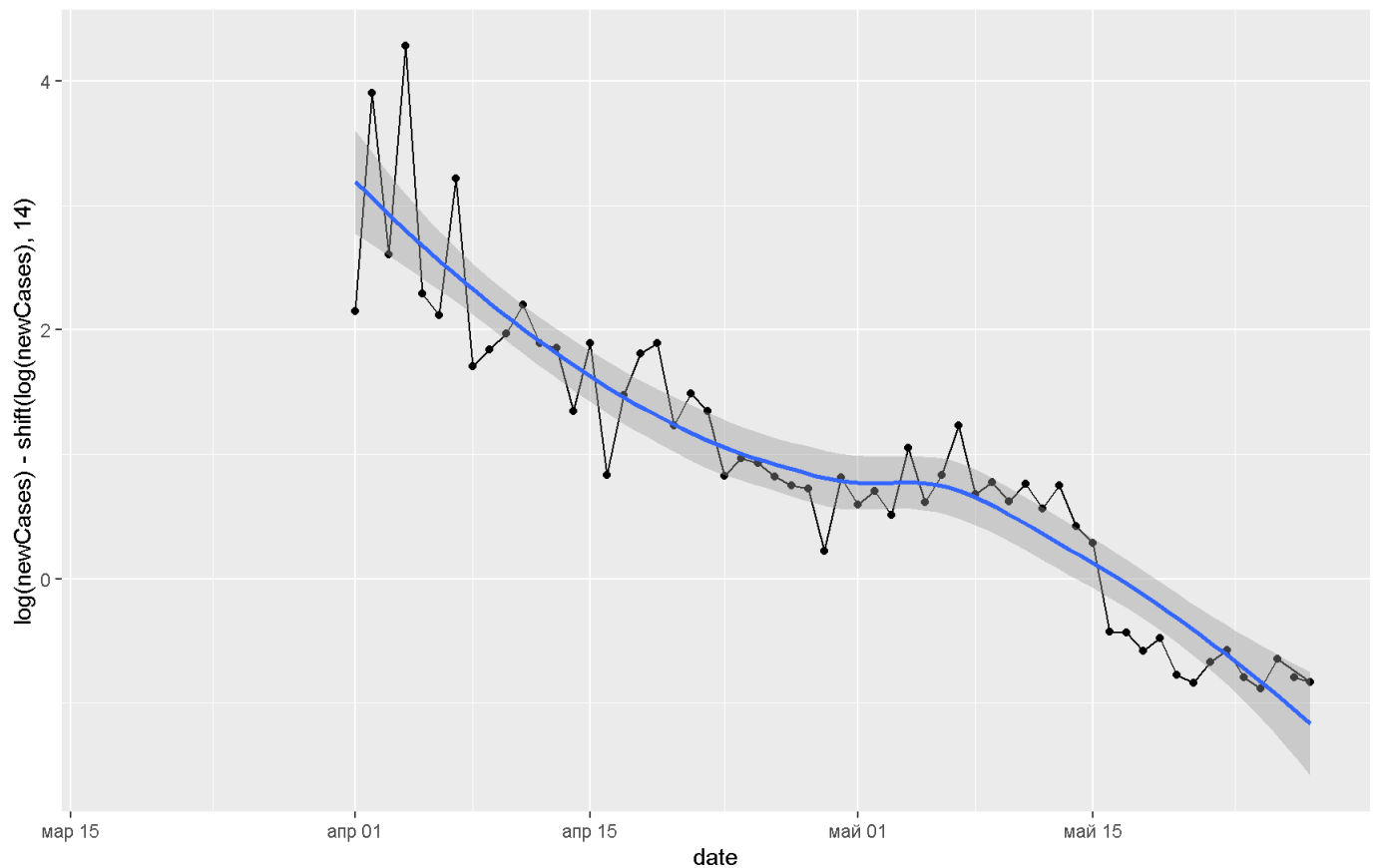
dlog(New daily COVID cases in Moscow)



dlog(New daily COVID cases in Moscow), 7d lag



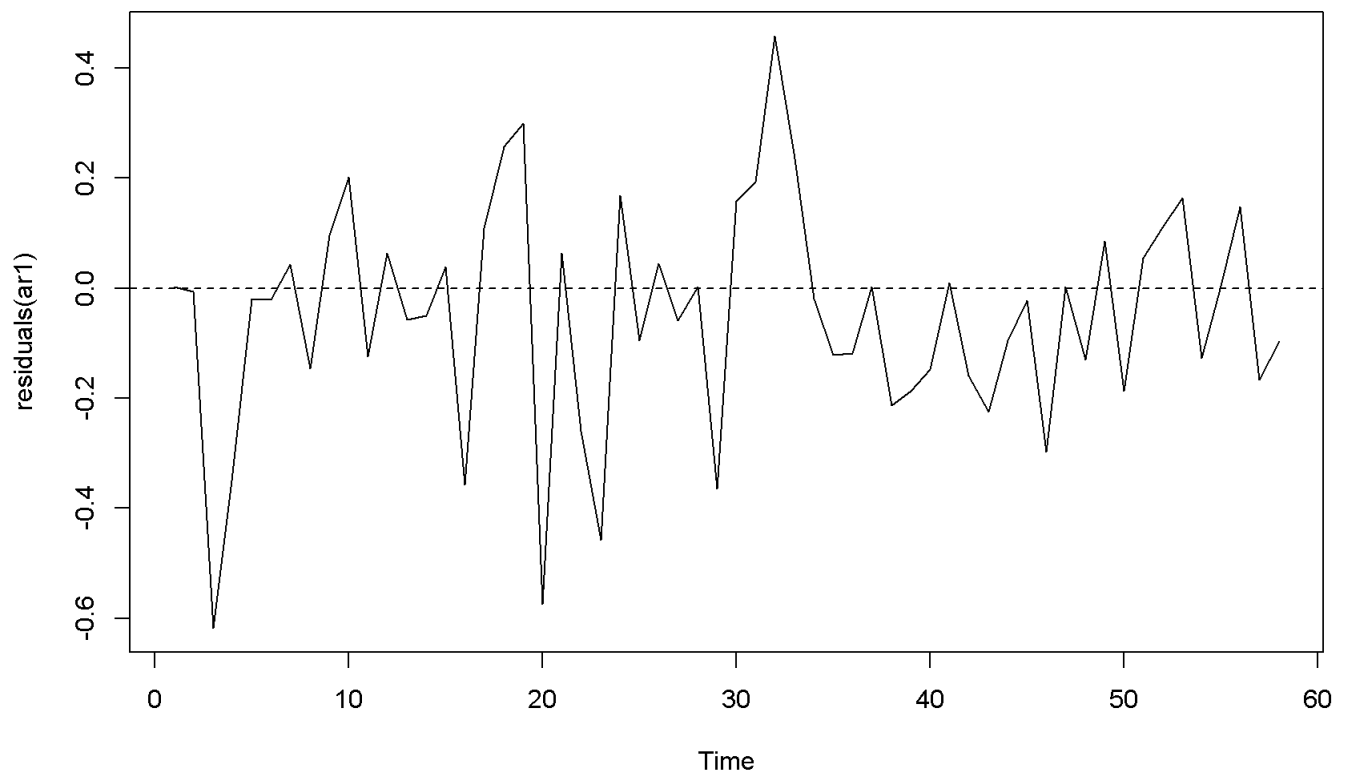
dlog(New daily COVID cases in Moscow), 14d lag



ARMA errors

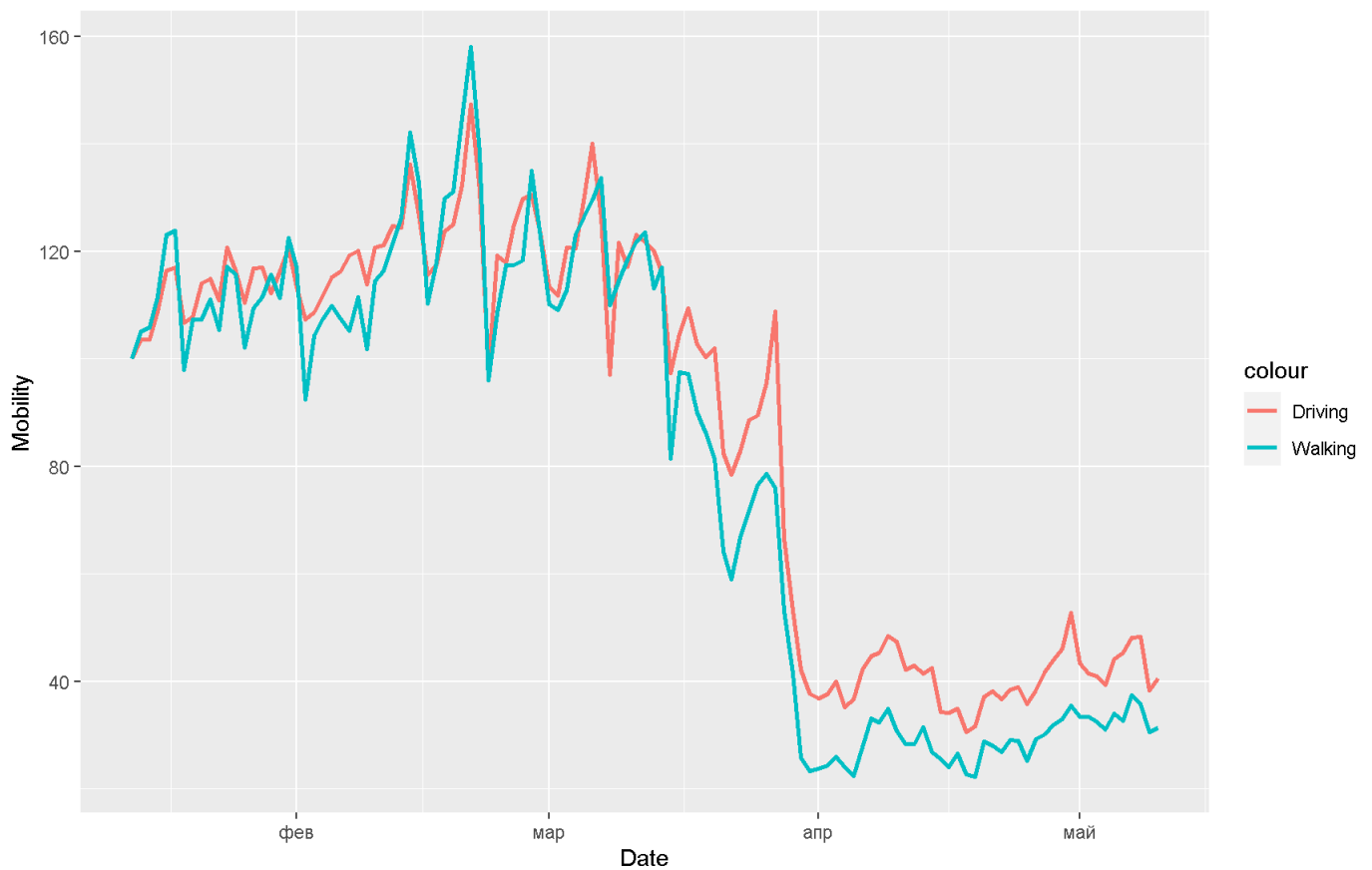
```
## Series: log(d1$newCases)
## Regression with ARIMA(0,2,2) errors
##
## Coefficients:
##      ma1      ma2      xreg
##      -1.3685  0.4588 -0.0545
## s.e.    0.1140  0.1099  0.1103
##
## sigma^2 estimated as 0.04692: log likelihood=6.44
## AIC=-4.89  AICc=-4.11  BIC=3.21
##
## Training set error measures:
##              ME      RMSE      MAE      MPE      MAPE      MASE
## Training set -0.04907045 0.2070673 0.1530651 -0.6989692 2.003948 0.8605882
##              ACF1
## Training set 0.06702633
```

ARIMA residuals



Apple mobility trends

Apple Mobility Trends Report - Moscow



Apple Mobility Trends Report (Moscow) + COVID new cases growth rate



Rolling sum over 2 weeks (aka active cases)

14d sum daily COVID-19 cases in Moscow (aka active cases)

