

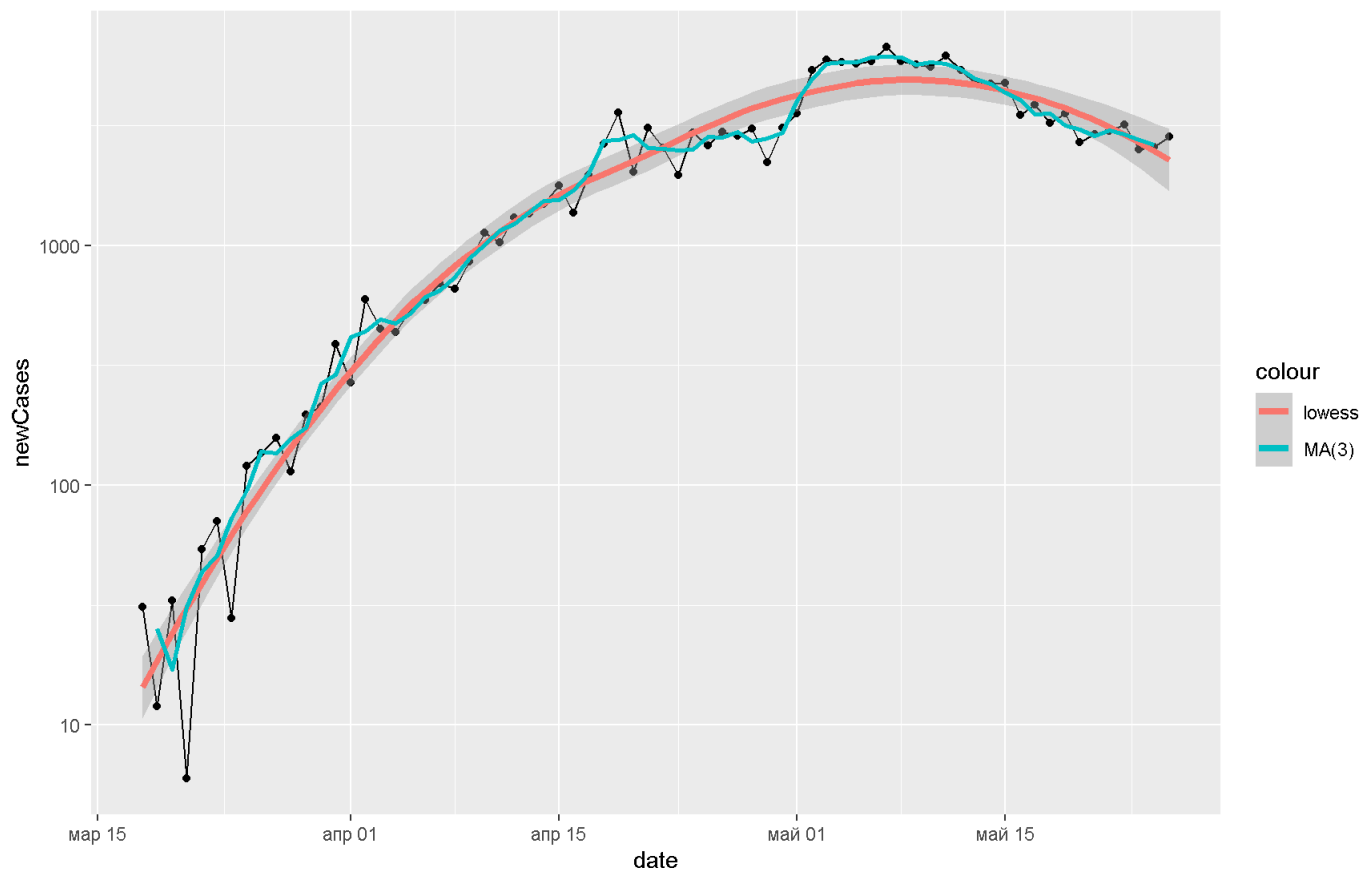
# COVID in Moscow

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

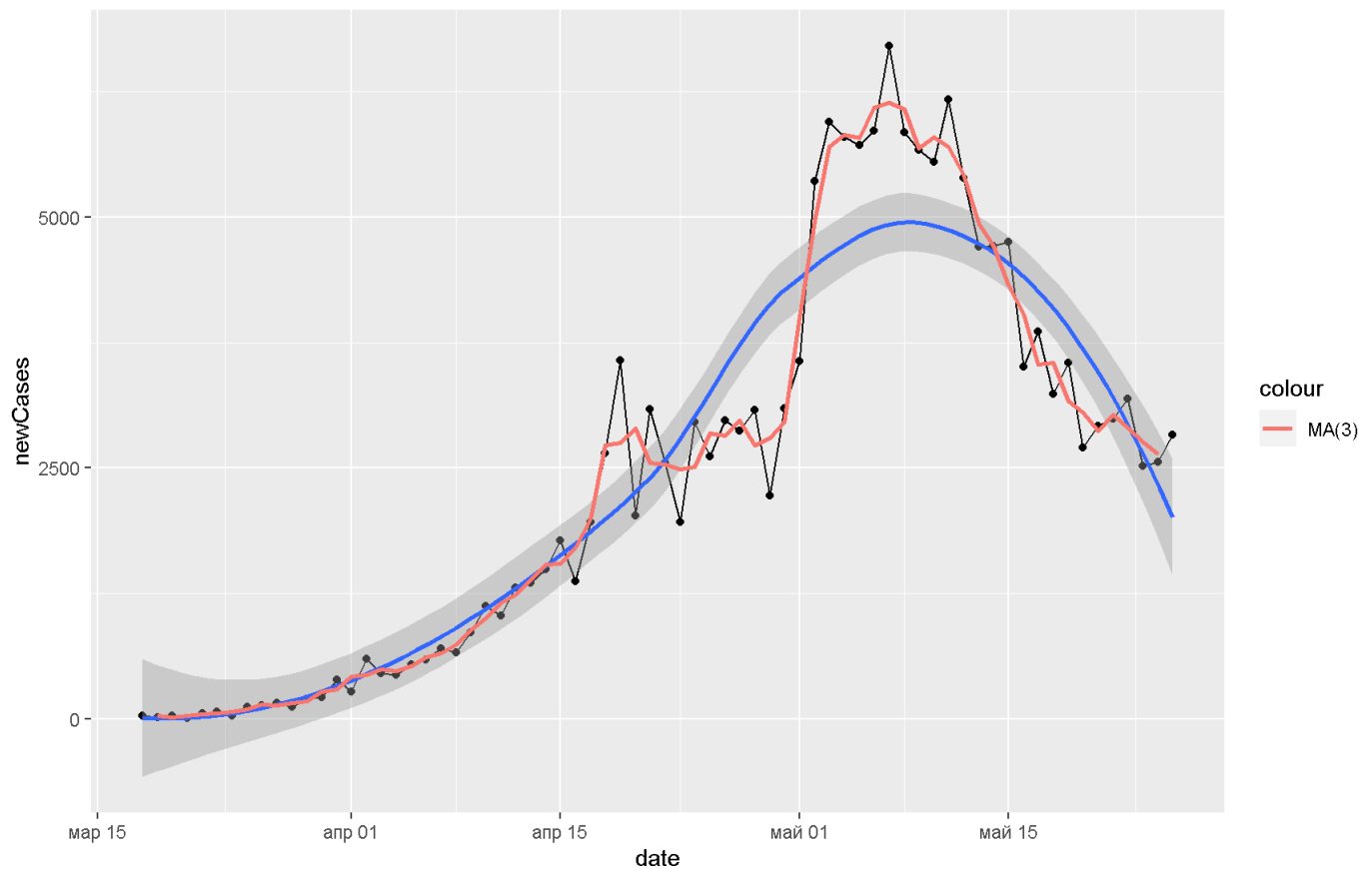
```
## [1] "CovidMoscowDB was NOT updated"
```

## 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
## -3.0490 -0.5902  0.3801  0.6521  1.3083
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  4.630685   0.211397   21.91  <2e-16 ***
## days_from_beg 0.070042   0.005287   13.25  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8938 on 68 degrees of freedom
## Multiple R-squared:  0.7207, Adjusted R-squared:  0.7166
## F-statistic: 175.5 on 1 and 68 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 30.541  1.344
##
## Meaningful coefficients of the linear terms:
##              Estimate Std. Error t value Pr(>|t|)
```

```

## (Intercept)      3.175955   0.152715   20.80   <2e-16 ***
## days_from_beg    0.161241   0.008744   18.44   <2e-16 ***
## U1.days_from_beg -0.156035   0.010717  -14.56      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4355 on 66 degrees of freedom
## Multiple R-Squared: 0.9357, Adjusted R-squared: 0.9327
##
## Convergence attained in 4 iter. (rel. change 0)
##
## ----- 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  1.237
## psi2.days_from_beg 49.567  1.489
##
## Meaningful coefficients of the linear terms:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.65796    0.15898  16.719   <2e-16 ***
## days_from_beg     0.23609    0.01806  13.073   <2e-16 ***
## U1.days_from_beg -0.16261    0.01897   -8.570      NA
## U2.days_from_beg -0.12586    0.01416   -8.886      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.333 on 64 degrees of freedom
## Multiple R-Squared: 0.9635, Adjusted R-squared: 0.9607
##
## Convergence attained in 3 iter. (rel. change 6.1708e-16)
##
## ----- 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 12.999  1.896
## psi2.days_from_beg 28.011  3.735
## psi3.days_from_beg 51.160  1.894
##
## Meaningful coefficients of the linear terms:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64535    0.16422  16.108   <2e-16 ***
## days_from_beg     0.23925    0.02147  11.143   <2e-16 ***
## U1.days_from_beg -0.12695    0.02891   -4.392      NA
## U2.days_from_beg -0.05671    0.02187   -2.593      NA
## U3.days_from_beg -0.10846    0.01789   -6.062      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3239 on 62 degrees of freedom
## Multiple R-Squared: 0.9666, Adjusted R-squared: 0.9628
##
## Convergence attained in 9 iter. (rel. change 4.9091e-06)
##
## ----- 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):

```

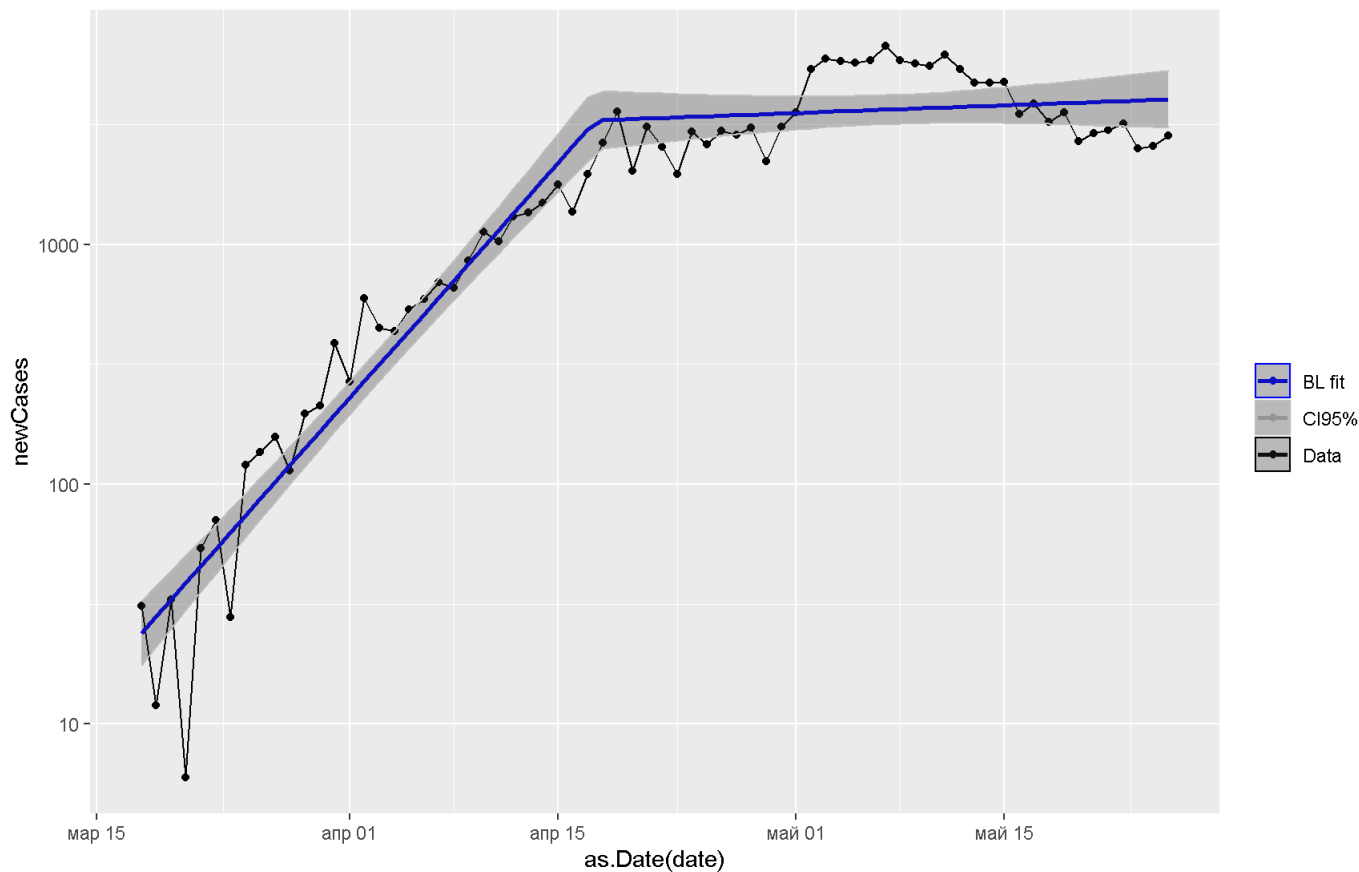
```

## ----- Break Point(s) -----
##               Est. St.Err
## psi1.days_from_beg 13.000  1.815
## psi2.days_from_beg 30.000  3.179
## psi3.days_from_beg 45.001  3.135
## psi4.days_from_beg 48.000  1.304
##
## Meaningful coefficients of the linear terms:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64432    0.16448  16.077 < 2e-16 ***
## days_from_beg     0.23950    0.02150  11.137 3.1e-16 ***
## U1.days_from_beg -0.12816    0.02684   -4.775    NA
## U2.days_from_beg -0.07294    0.02517   -2.898    NA
## U3.days_from_beg  0.16598    0.23017    0.721    NA
## U4.days_from_beg -0.25352    0.22965   -1.104    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3244 on 60 degrees of freedom
## Multiple R-Squared: 0.9675, Adjusted R-squared: 0.9627
##
## Convergence attained in 1 iter. (rel. change -3.5944e-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  1.724
## psi2.days_from_beg 32.000  2.382
## psi3.days_from_beg 42.650  1.509
## psi4.days_from_beg 45.449  1.735
## psi5.days_from_beg 51.263  4.593
##
## Meaningful coefficients of the linear terms:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64465    0.16105  16.422 <2e-16 ***
## days_from_beg     0.23942    0.02106  11.371 <2e-16 ***
## U1.days_from_beg -0.12835    0.02491   -5.153    NA
## U2.days_from_beg -0.10845    0.03741   -2.899    NA
## U3.days_from_beg  0.27173    0.22728    1.196    NA
## U4.days_from_beg -0.26410    0.23706   -1.114    NA
## U5.days_from_beg -0.06317    0.07728   -0.817    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3176 on 58 degrees of freedom
## Multiple R-Squared: 0.9699, Adjusted R-squared: 0.9642
##
## Convergence attained in 12 iter. (rel. change 8.5346e-08)
## breakpoint estimate(s): 0.7288397 12.95754 32.71265 33.94685 42.02732 49.09063
##
## ----- 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  1.768
## psi2.days_from_beg 32.000  2.222
## psi3.days_from_beg 42.673  1.490
## psi4.days_from_beg 45.546  1.654
## psi5.days_from_beg 53.811  4.271
## psi6.days_from_beg 62.940  5.378
##
## Meaningful coefficients of the linear terms:
##

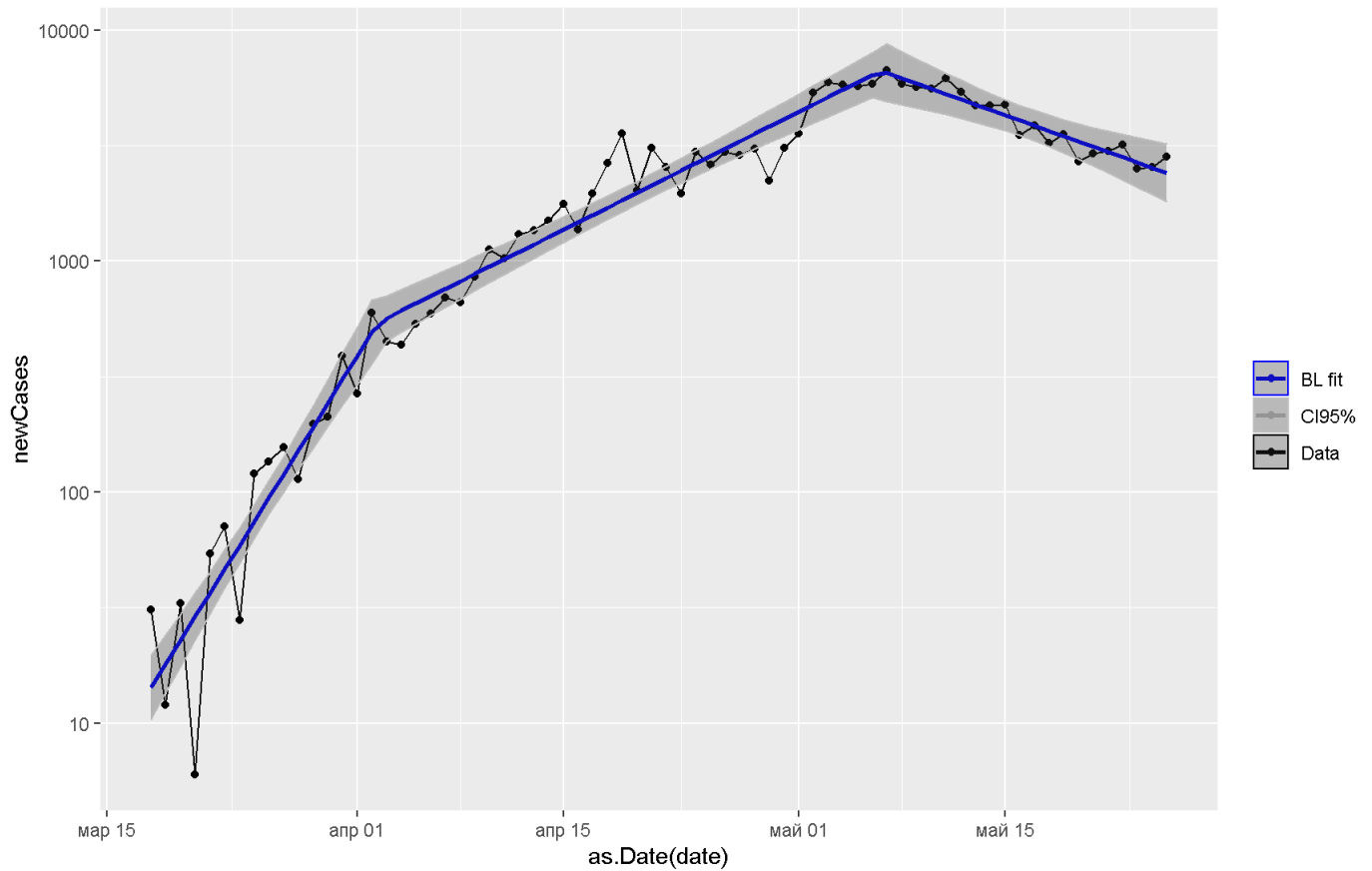
```

```
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)      2.64473    0.16292  16.234 < 2e-16 ***
## days_from_beg     0.23940    0.02130  11.239 5.6e-16 ***
## U1.days_from_beg -0.12837    0.02582  -4.972    NA
## U2.days_from_beg -0.10820    0.03393  -3.189    NA
## U3.days_from_beg  0.27254    0.22923   1.189    NA
## U4.days_from_beg -0.27642    0.23252  -1.189    NA
## U5.days_from_beg -0.07413    0.06464  -1.147    NA
## U6.days_from_beg  0.05959    0.07353   0.810    NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3213 on 56 degrees of freedom
## Multiple R-Squared:  0.9703, Adjusted R-squared:  0.9634
##
## Convergence attained in 1 iter. (rel. change 3.5549e-07)
```

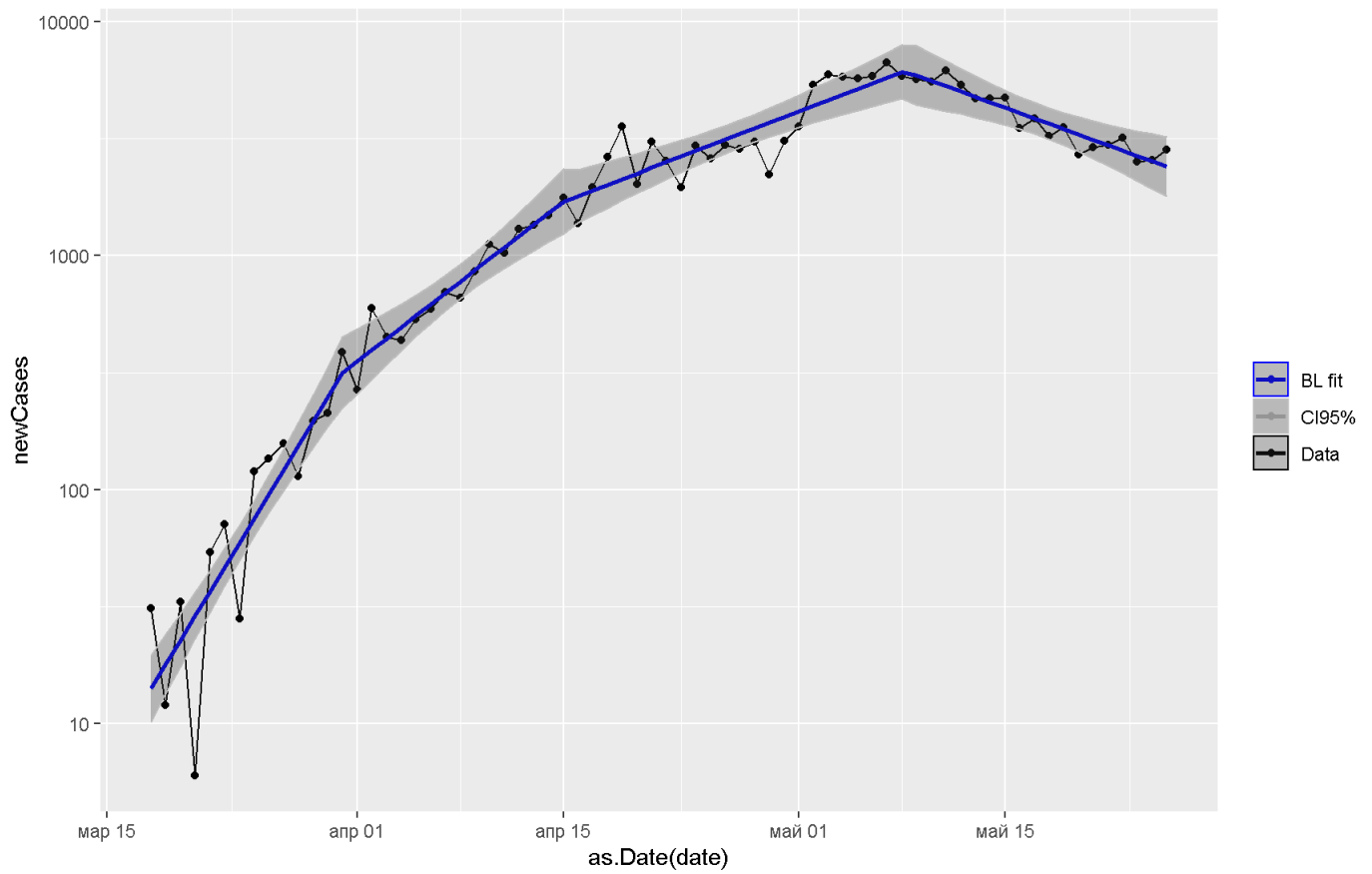
New daily COVID cases in Moscow (npsi=1)



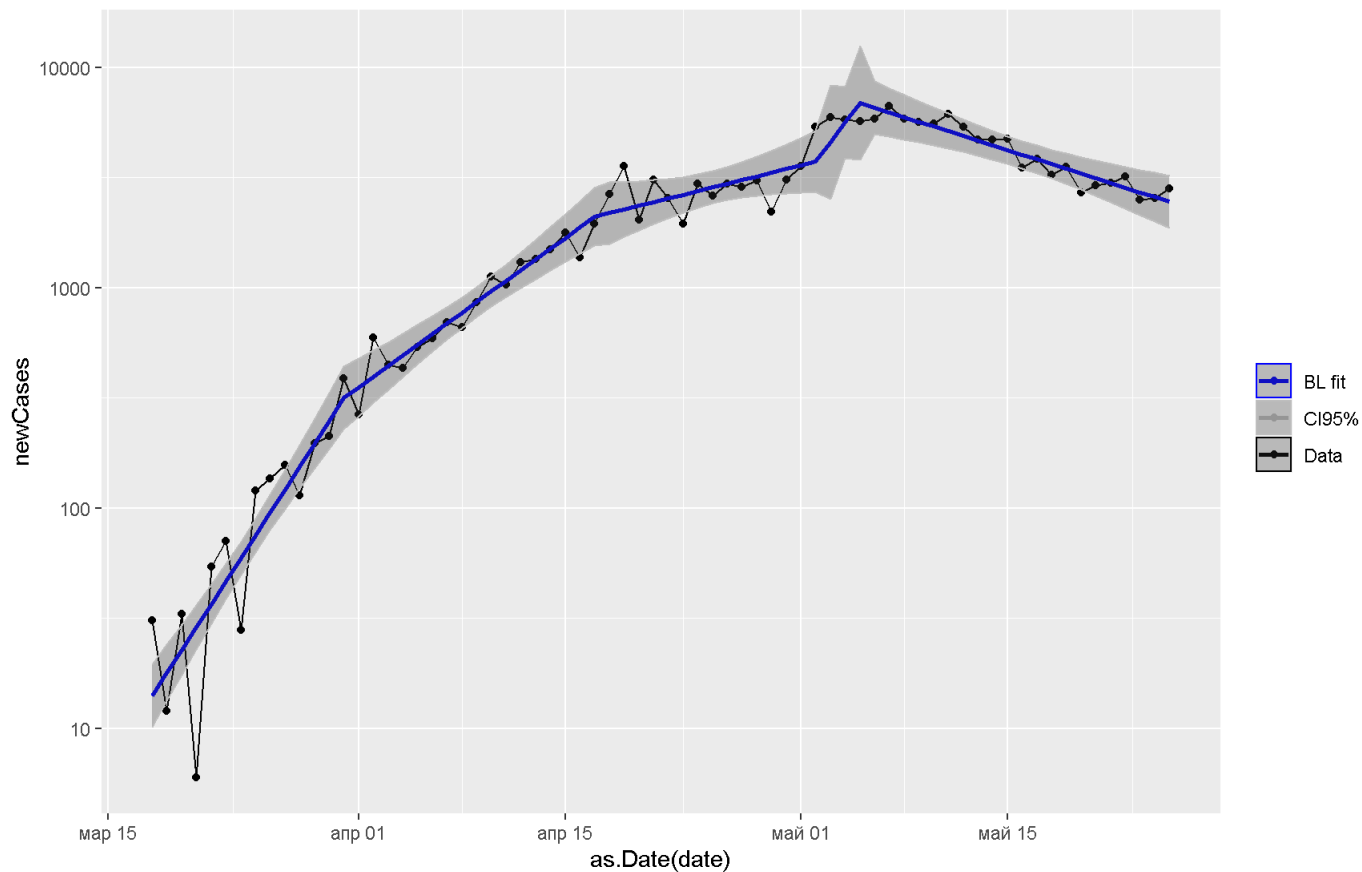
New daily COVID cases in Moscow (npsi=2)



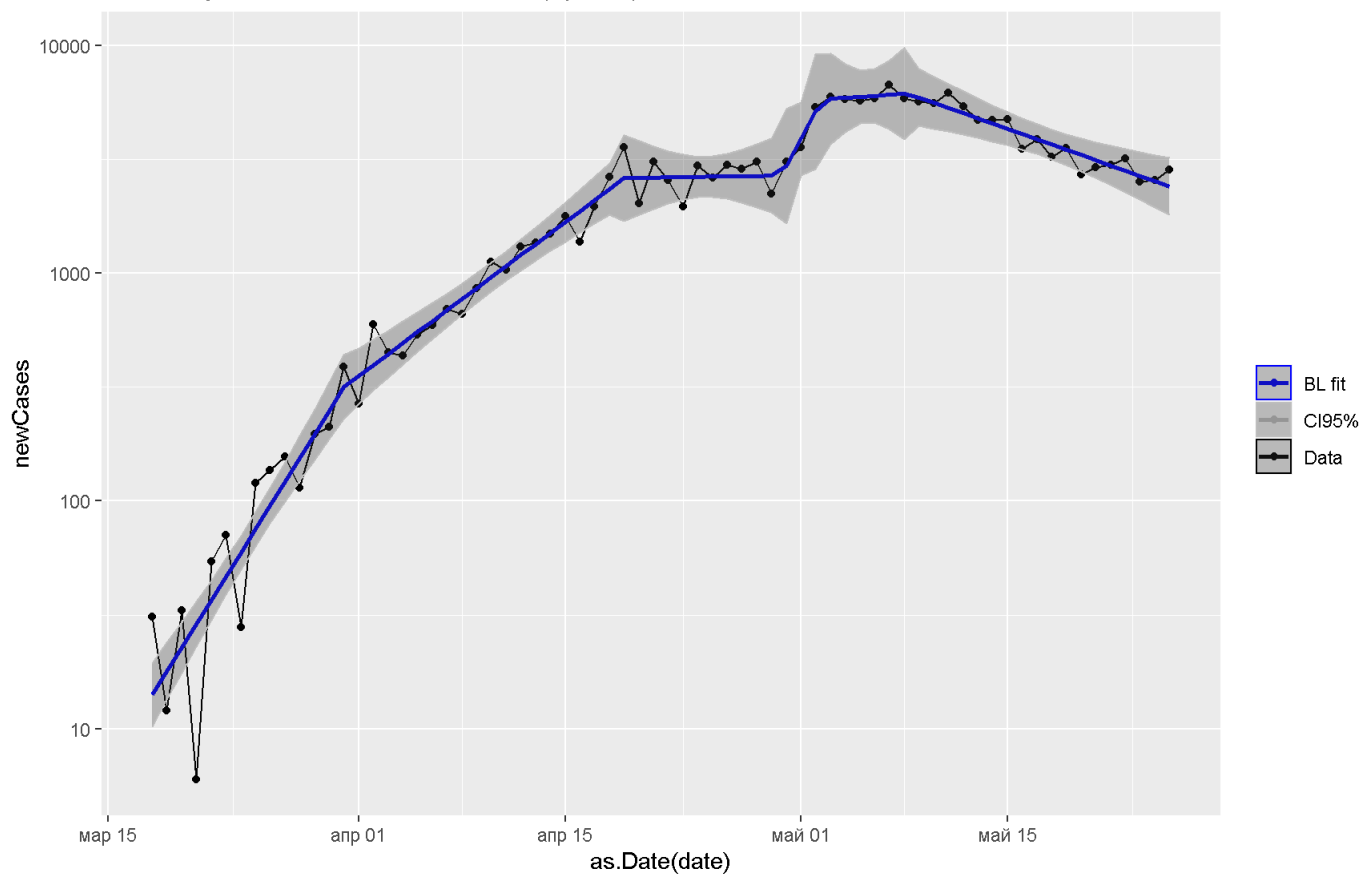
New daily COVID cases in Moscow (npsi=3)



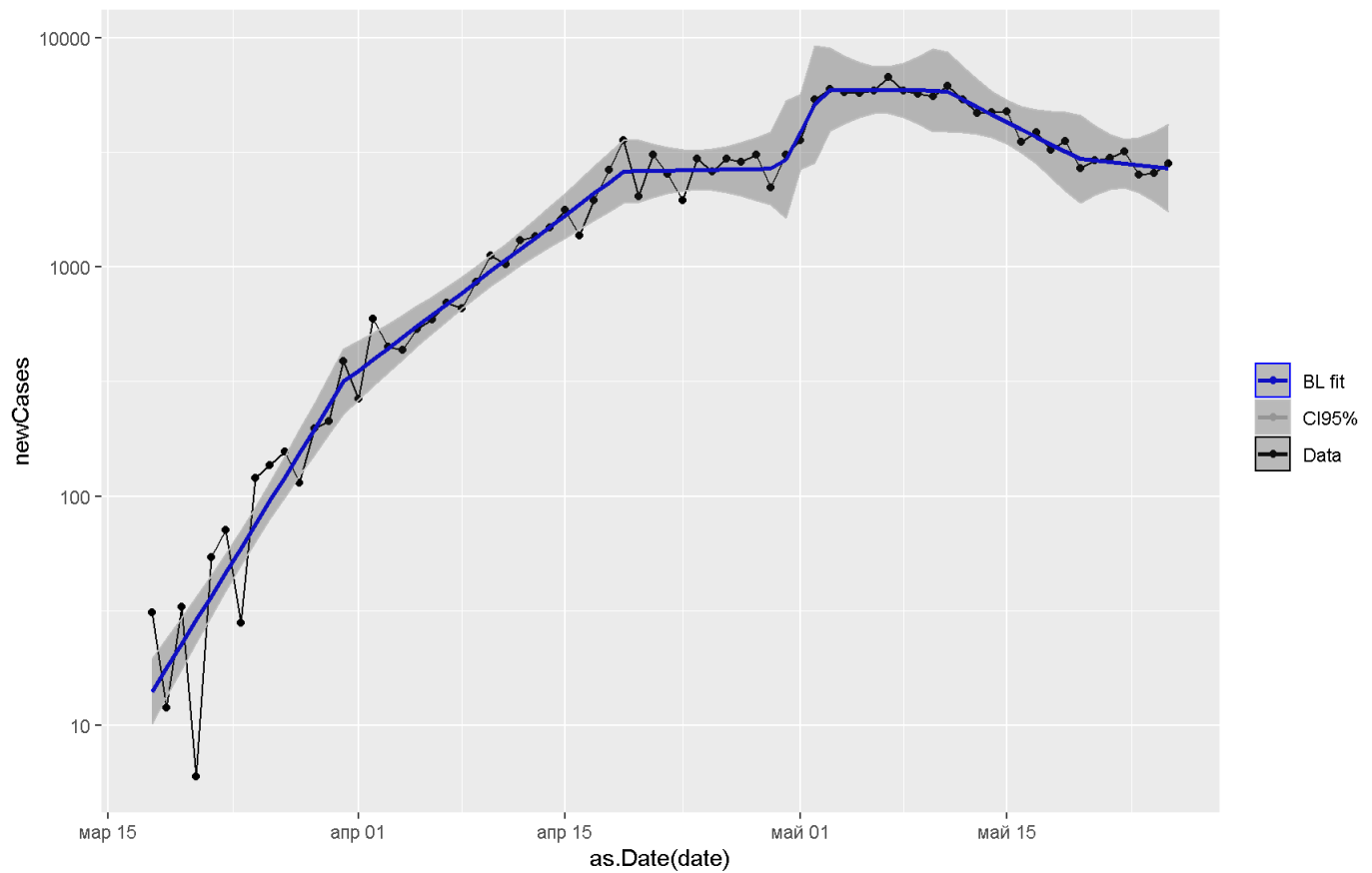
New daily COVID cases in Moscow (npsi=4)



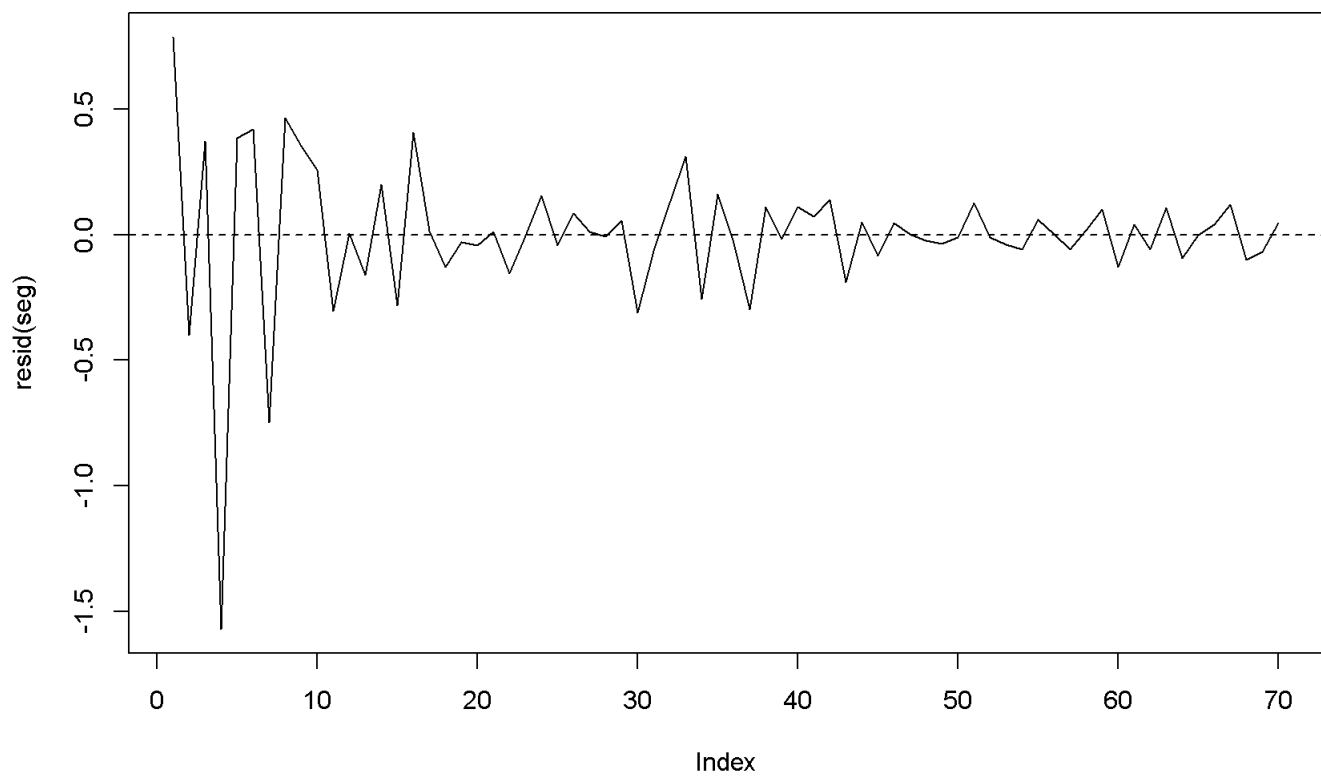
New daily COVID cases in Moscow (npsi=5)



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  0.1612400 0.0087444 18.43900  0.1437800  0.178700
## slope2  0.0052063 0.0061957  0.84031 -0.0071639  0.017577
```



```

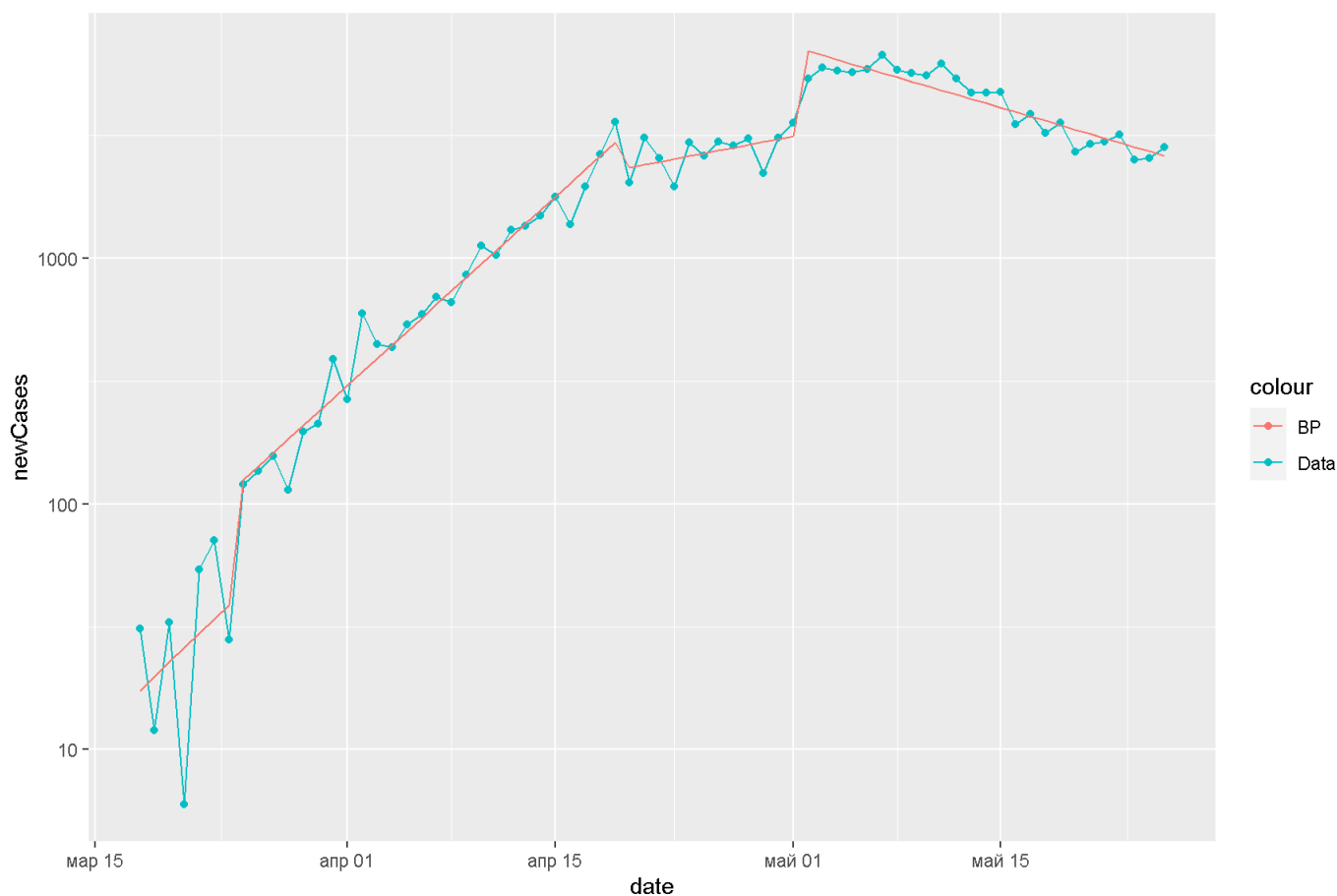
##
## Doubling of cases:
##      slope1      slope2
##      4.298854 133.136235
##
## ----- N. Breaking points = 2 -----
## Slopes
## $days_from_beg
##      Est. St.Err. t value CI(95%).l CI(95%).u
## slope1 0.236090 0.018059 13.0730 0.200010 0.272160
## slope2 0.073471 0.005821 12.6220 0.061842 0.085100
## slope3 -0.052392 0.012913 -4.0573 -0.078189 -0.026595
##
## Doubling of cases:
##      slope1      slope2      slope3
##      2.935945  9.434296 -13.230019
##
## ----- N. Breaking points = 3 -----
## Slopes
## $days_from_beg
##      Est. St.Err. t value CI(95%).l CI(95%).u
## slope1 0.239250 0.021472 11.1430 0.196330 0.282170
## slope2 0.112300 0.019354  5.8022 0.073608 0.150980
## slope3 0.055584 0.010180  5.4600 0.035234 0.075934
## slope4 -0.052878 0.014713 -3.5940 -0.082289 -0.023467
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4
##      2.897167  6.172281 12.470264 -13.108423
##
## ----- N. Breaking points = 4 -----
## Slopes
## $days_from_beg
##      Est. St.Err. t value CI(95%).l CI(95%).u
## slope1 0.239500 0.021505 11.13700 0.19649000 0.282520
## slope2 0.111340 0.016058  6.93380 0.07922200 0.143460
## slope3 0.038406 0.019384  1.98130 -0.00036775 0.077180
## slope4 0.204390 0.229360  0.89115 -0.25439000 0.663170
## slope5 -0.049135 0.011689 -4.20350 -0.07251700 -0.025754
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5
##      2.894143  6.225500 18.047888  3.391297 -14.106995
##
## ----- N. Breaking points = 5 -----
## Slopes
## $days_from_beg
##      Est. St.Err. t value CI(95%).l CI(95%).u
## slope1 0.2394200 0.021056 11.371000 0.197270 0.281570
## slope2 0.1110700 0.013302  8.349800 0.084445 0.137700
## slope3 0.0026226 0.034966  0.075004 -0.067369 0.072614
## slope4 0.2743500 0.224570  1.221700 -0.175180 0.723880
## slope5 0.0102560 0.075919  0.135090 -0.141710 0.162220
## slope6 -0.0529130 0.014429 -3.667300 -0.081795 -0.024031
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5      slope6
##      2.895110  6.240634 264.297712  2.526507 67.584553 -13.099752
##
## ----- N. Breaking points = 6 -----
## Slopes
## $days_from_beg
##      Est. St.Err. t value CI(95%).l CI(95%).u
## slope1 0.2394000 0.021300 11.239000 0.196730 0.2820700
## slope2 0.1110300 0.014596  7.607000 0.081791 0.1402700
## slope3 0.0028346 0.030633  0.092536 -0.058530 0.0642000
## slope4 0.2753800 0.227180  1.212200 -0.179710 0.7304700
## slope5 -0.0010377 0.049574 -0.020933 -0.100350 0.0982700
## slope6 -0.0751710 0.041476 -1.812400 -0.158260 0.0079165
## slope7 -0.0155830 0.060715 -0.256650 -0.137210 0.1060400
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5      slope6      slope7

```

```
##          slope1          slope2          slope3          slope4          slope5          slope6          slope7
## 2.895352    6.242882   244.530862    2.517057 -667.964904   -9.220939   -44.480984
```

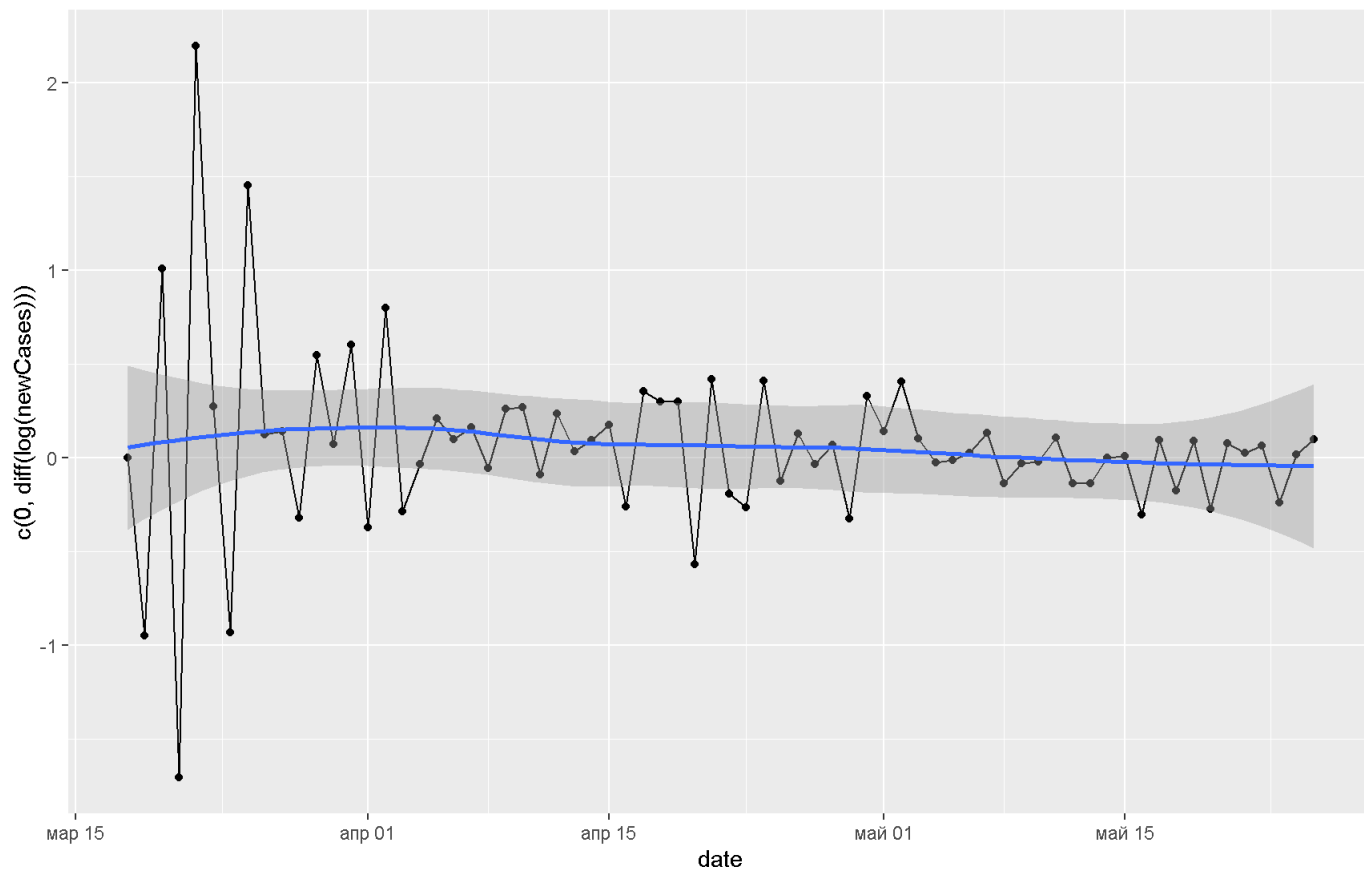
## Struct change

```
##
## 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:
## 0.1 0.4714286 0.6428571
```

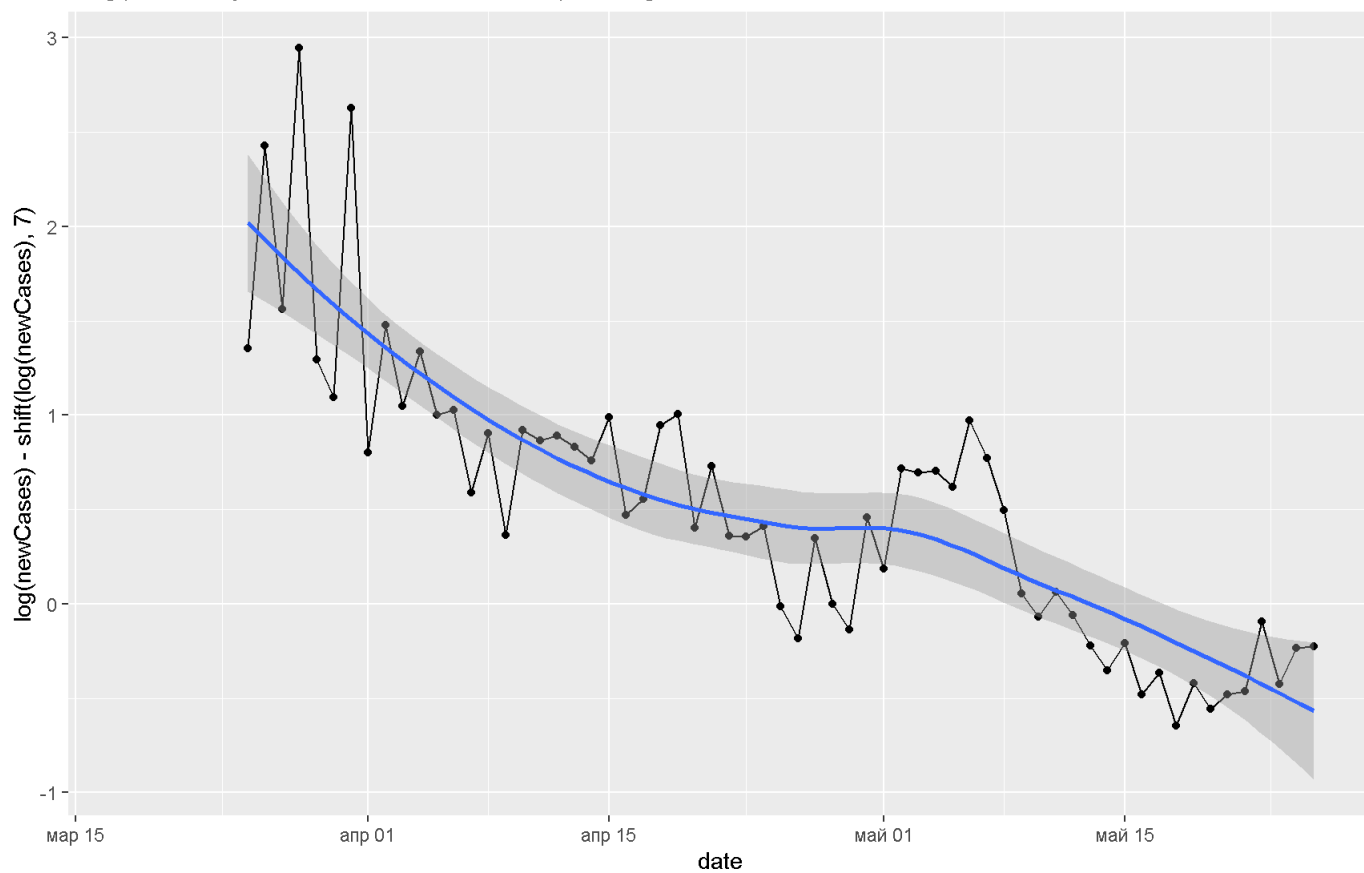


## Дифференциалы

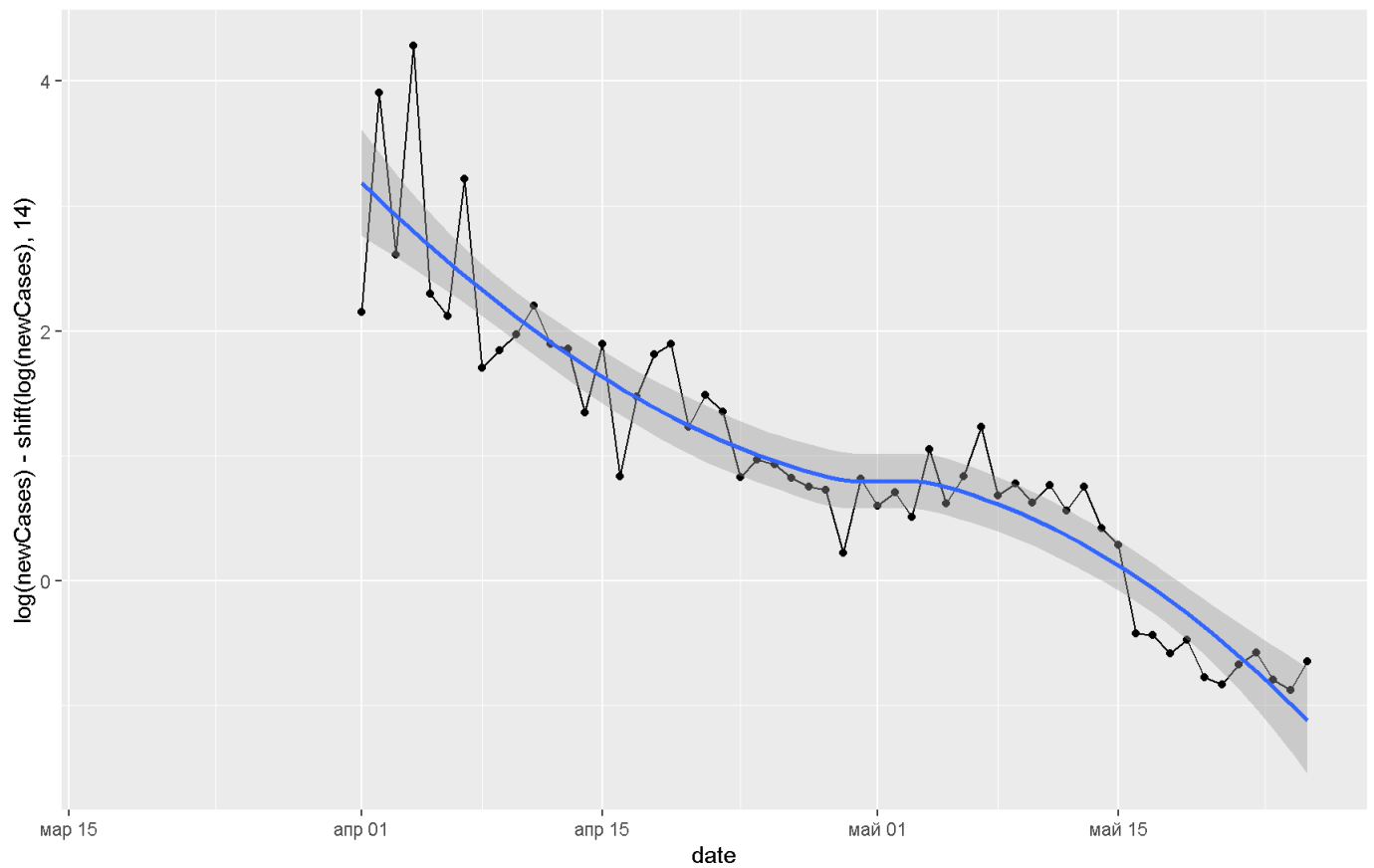
dlog(New daily COVID cases in Moscow)



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



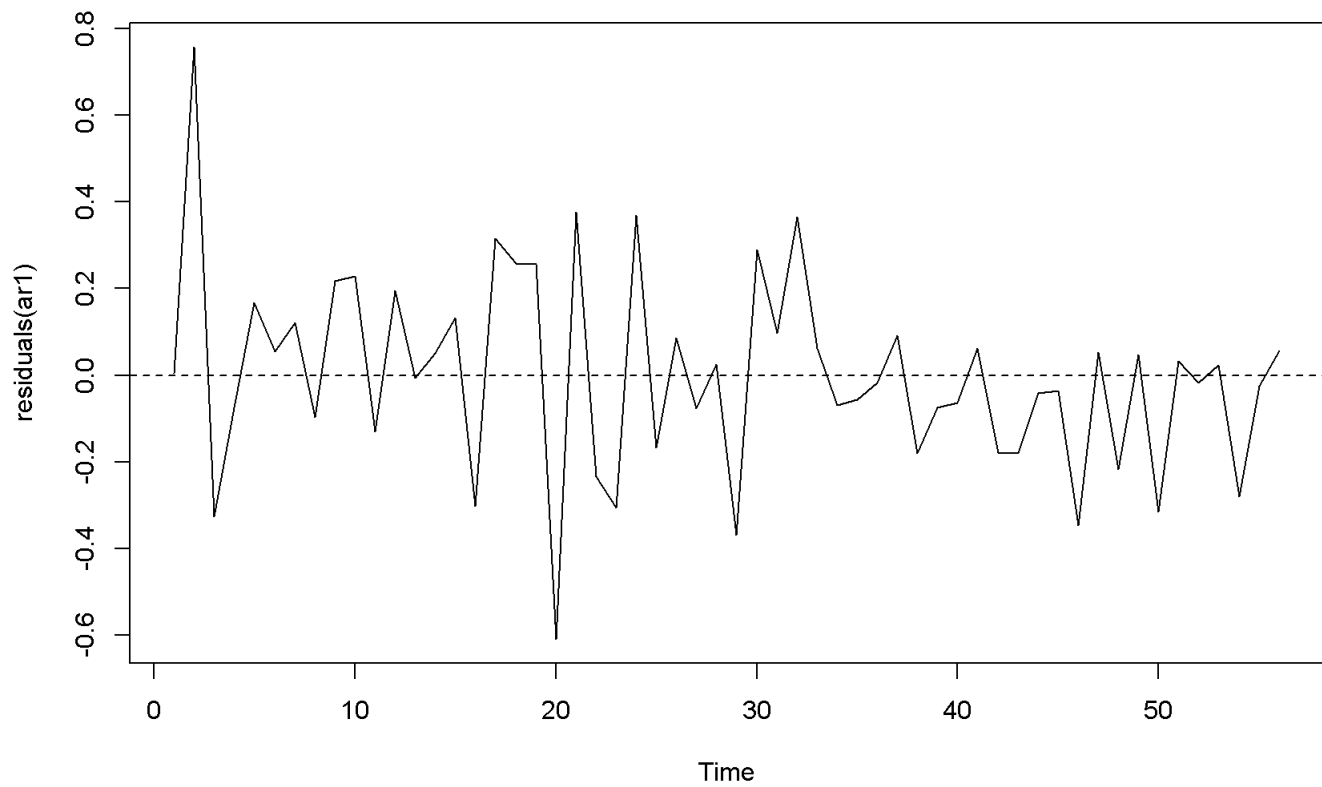
dlog(New daily COVID cases in Moscow), 14d lag



## ARMA errors

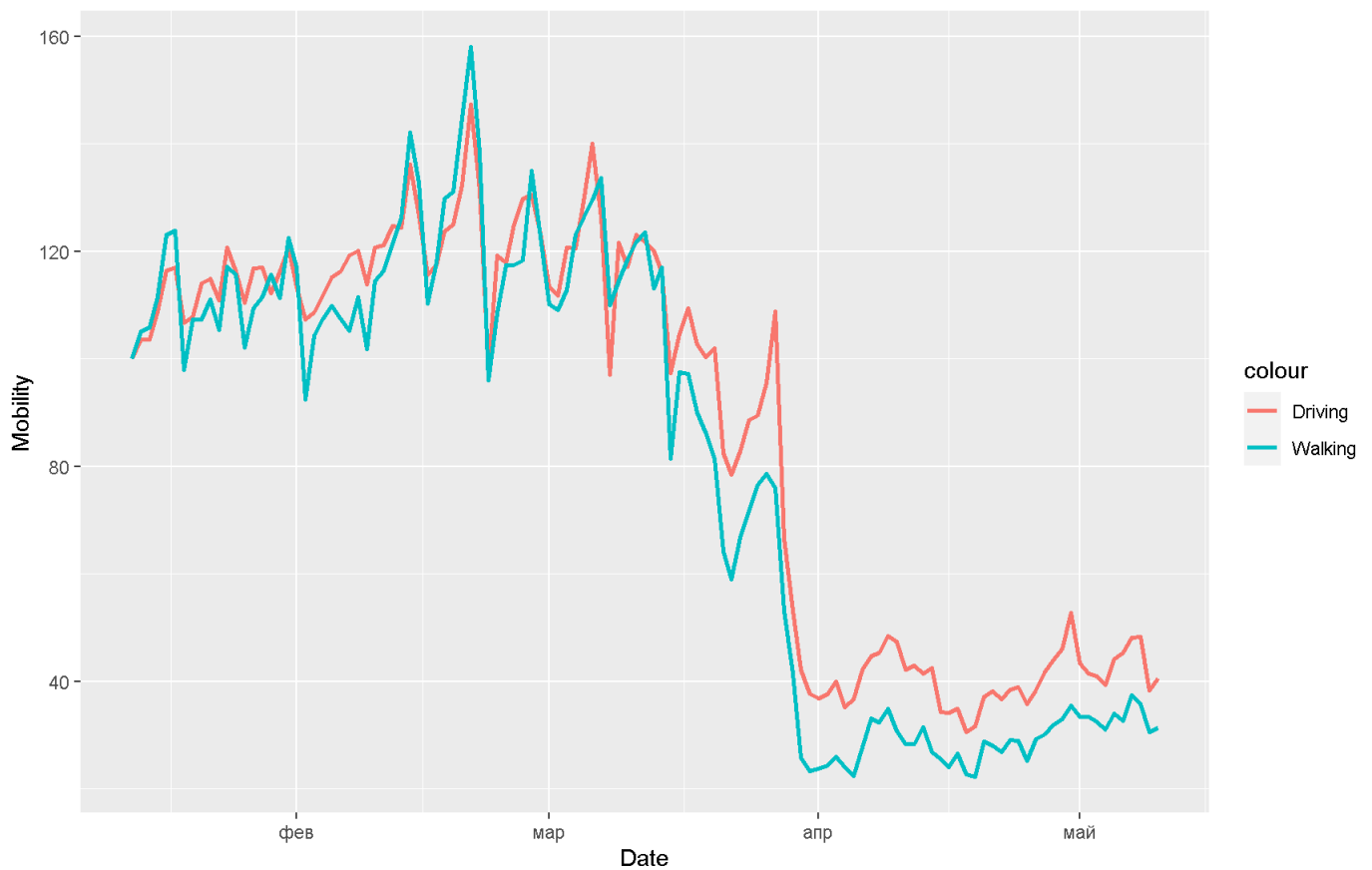
```
## Series: log(d1$newCases)
## Regression with ARIMA(0,1,0) errors
##
## Coefficients:
##      xreg
##      0.0429
## s.e.  0.0311
##
## sigma^2 estimated as 0.05428:  log likelihood=2.59
## AIC=-1.17   AICc=-0.94   BIC=2.84
##
## Training set error measures:
##              ME      RMSE      MAE      MPE      MAPE      MASE      ACF1
## Training set 8.904142e-05 0.228788 0.1713657 0.03301363 2.268126 0.9640508 -0.3048746
```

### ARIMA residuals

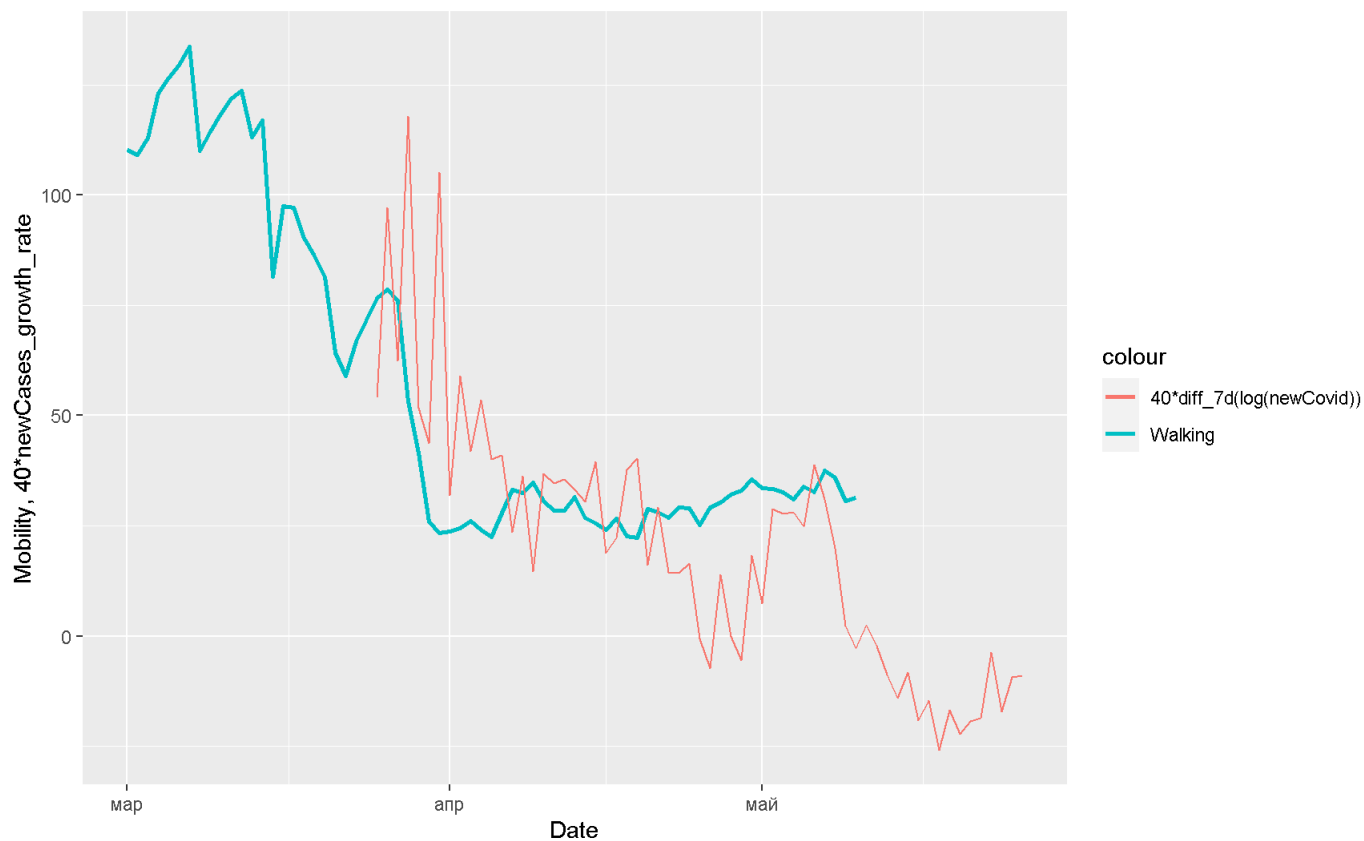


## Apple mobility trends

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)

