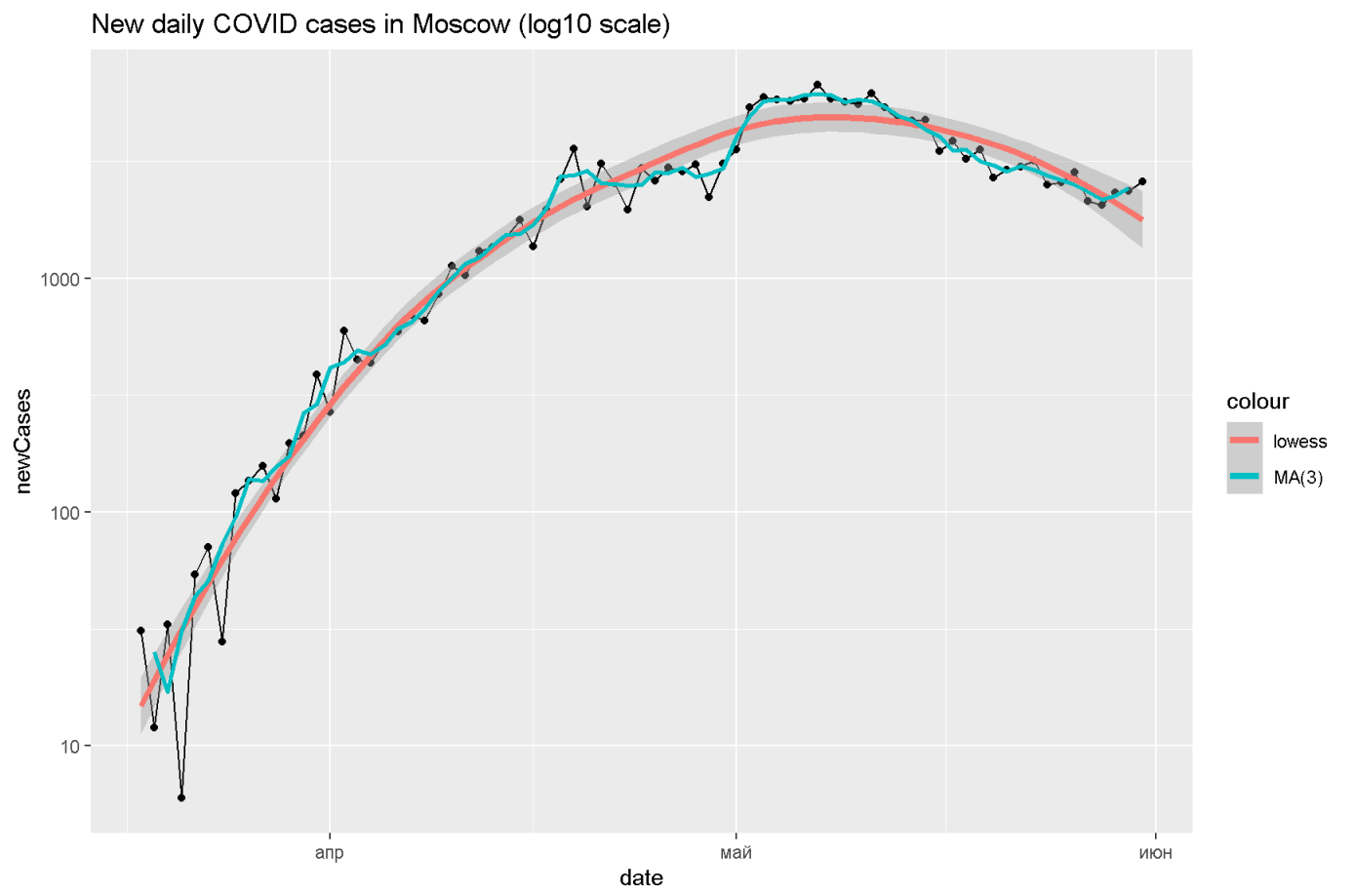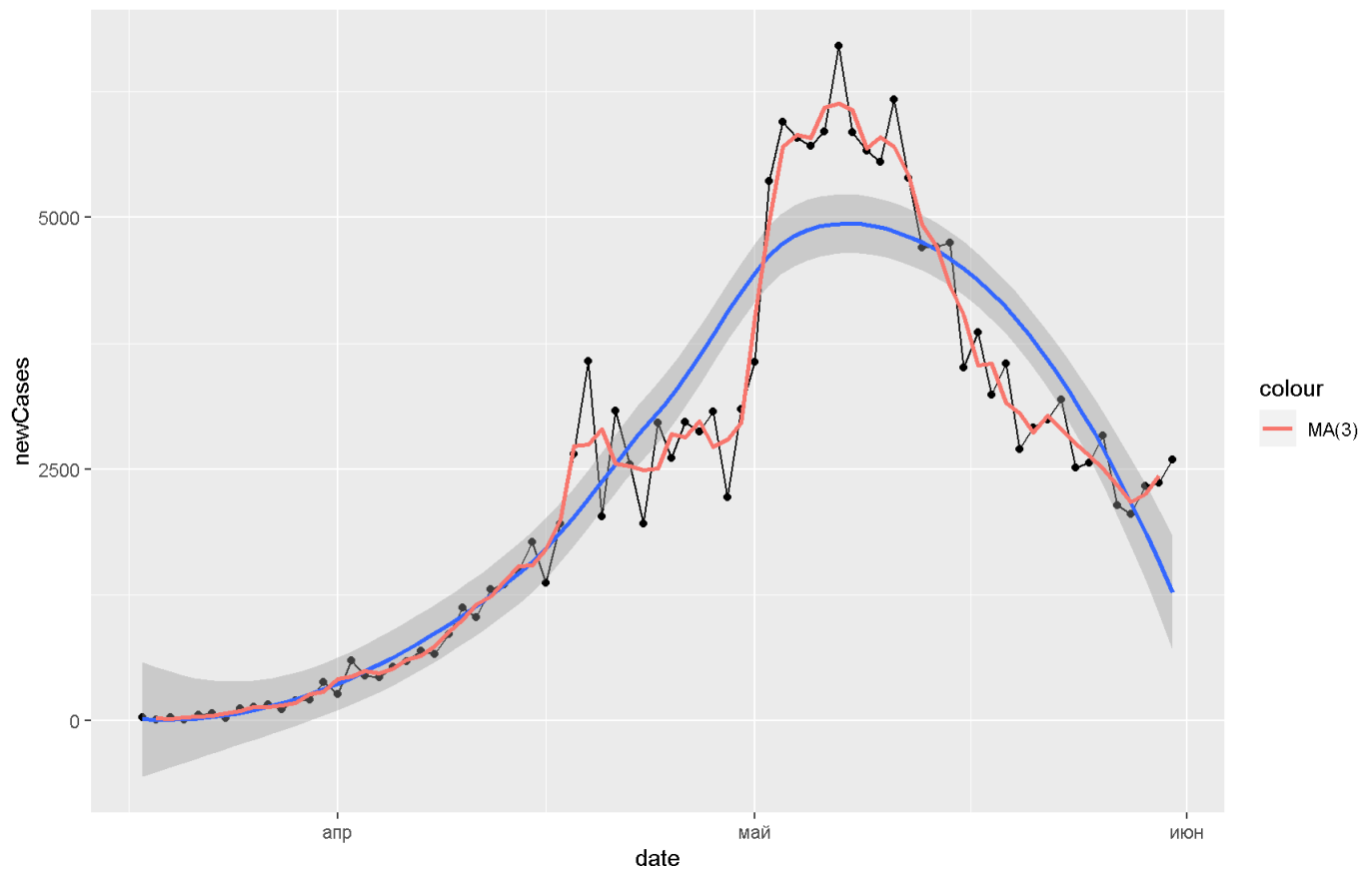# COVID in Moscow

```
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
## -3.2480 -0.7365  0.3385  0.7486  1.3892
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)    4.85860    0.22162   21.92   <2e-16 ***
## days_from_beg  0.06039    0.00517   11.68   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9692 on 73 degrees of freedom
## Multiple R-squared:  0.6515, Adjusted R-squared:  0.6467
## F-statistic: 136.5 on 1 and 73 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 31.604  1.251
##
## Meaningful coefficients of the linear terms:
##                 Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept)        3.192574   0.150909    21.16   <2e-16 ***
## days_from_beg      0.159579   0.008365    19.08   <2e-16 ***
## U1.days_from_beg  -0.163356   0.009939   -16.44       NA
## ---
## Signif. codes:   0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4369 on 71 degrees of freedom
## Multiple R-Squared: 0.9311,  Adjusted R-squared: 0.9282
##
## Convergence attained in 3 iter. (rel. change 1.3012e-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  1.203
## psi2.days_from_beg 49.239  1.416
##
## Meaningful coefficients of the linear terms:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.65796    0.15451  17.202   <2e-16 ***
## days_from_beg     0.23609    0.01755  13.451   <2e-16 ***
## U1.days_from_beg -0.16261    0.01844  -8.818       NA
## U2.days_from_beg -0.12096    0.01061 -11.401       NA
## ---
## Signif. codes:   0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3236 on 69 degrees of freedom
## Multiple R-Squared: 0.9633,  Adjusted R-squared: 0.9606
##
## Convergence attained in 3 iter. (rel. change 0)
##
## -------------  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  1.879
## psi2.days_from_beg 27.978  3.880
## psi3.days_from_beg 50.631  1.787
##
## Meaningful coefficients of the linear terms:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.64523    0.15951  16.583   <2e-16 ***
## days_from_beg     0.23928    0.02086  11.473   <2e-16 ***
## U1.days_from_beg -0.12706    0.02949  -4.308       NA
## U2.days_from_beg -0.05621    0.02308  -2.436       NA
## U3.days_from_beg -0.10285    0.01356  -7.586       NA
## ---
## Signif. codes:   0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3146 on 67 degrees of freedom
## Multiple R-Squared: 0.9663,  Adjusted R-squared: 0.9628
##
## Convergence attained in 6 iter. (rel. change 9.7397e-07)
##
## -------------  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  1.759
## psi2.days_from_beg 30.000  3.091
## psi3.days_from_beg 45.001  3.220
## psi4.days_from_beg 48.000  1.301
##
## Meaningful coefficients of the linear terms:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.64425    0.15948  16.580   <2e-16 ***
## days_from_beg     0.23952    0.02085  11.487   <2e-16 ***
## U1.days_from_beg -0.12822    0.02602  -4.927       NA
## U2.days_from_beg -0.07272    0.02441  -2.980       NA
## U3.days_from_beg  0.15671    0.22318   0.702       NA
## U4.days_from_beg -0.24137    0.22254  -1.085       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3145 on 65 degrees of freedom
## Multiple R-Squared: 0.9673,  Adjusted R-squared: 0.9628
##
## Convergence attained in 1 iter. (rel. change -4.8996e-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  1.696
## psi2.days_from_beg 31.998  2.119
## psi3.days_from_beg 42.622  1.460
## psi4.days_from_beg 45.345  1.767
## psi5.days_from_beg 50.159  4.259
##
## Meaningful coefficients of the linear terms:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.64473    0.15617  16.934   <2e-16 ***
## days_from_beg     0.23940    0.02042  11.724   <2e-16 ***
## U1.days_from_beg -0.12829    0.02475  -5.183       NA
## U2.days_from_beg -0.10876    0.03253  -3.343       NA
## U3.days_from_beg  0.27192    0.21975   1.237       NA
## U4.days_from_beg -0.25514    0.23856  -1.069       NA
## U5.days_from_beg -0.06629    0.09781  -0.678       NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.308 on 63 degrees of freedom
## Multiple R-Squared: 0.9696,  Adjusted R-squared: 0.9643
##
## Convergence attained in 13 iter. (rel. change 1.0157e-06)
##
## -------------- 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 13.027  1.769
## psi2.days_from_beg 32.001  2.158
## psi3.days_from_beg 43.393  1.408
## psi4.days_from_beg 45.260  1.130
## psi5.days_from_beg 54.000  4.216
## psi6.days_from_beg 63.014  5.520
##
## Meaningful coefficients of the linear terms:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.64450    0.16347  16.377   <2e-16 ***
```

```
## (Intercept)         2.64450    0.16247  16.277  < 2e-16 ***
## days_from_beg        0.23946    0.02298  10.422 3.59e-15 ***
## U1.days_from_beg    -0.12901    0.02640  -4.886      NA
## U2.days_from_beg    -0.10386    0.02900  -3.582      NA
## U3.days_from_beg     0.39854    0.43914   0.908      NA
## U4.days_from_beg    -0.40752    0.44098  -0.924      NA
## U5.days_from_beg    -0.07297    0.06236  -1.170      NA
## U6.days_from_beg     0.05096    0.04771   1.068      NA
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.31 on 61 degrees of freedom
## Multiple R-Squared: 0.9702,  Adjusted R-squared: 0.9639
##
## Convergence attained in 7 iter. (rel. change 4.2113e-06)
```
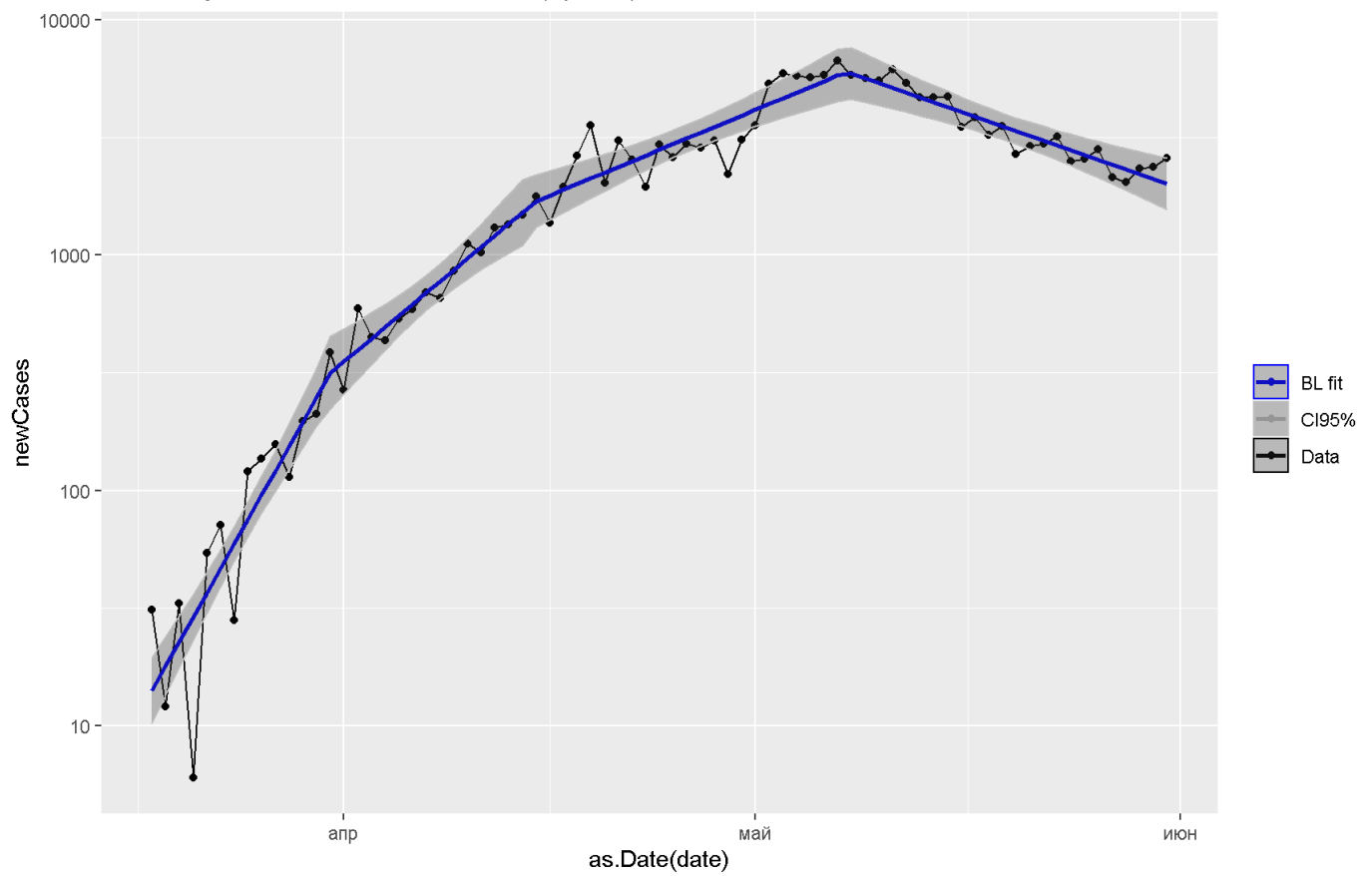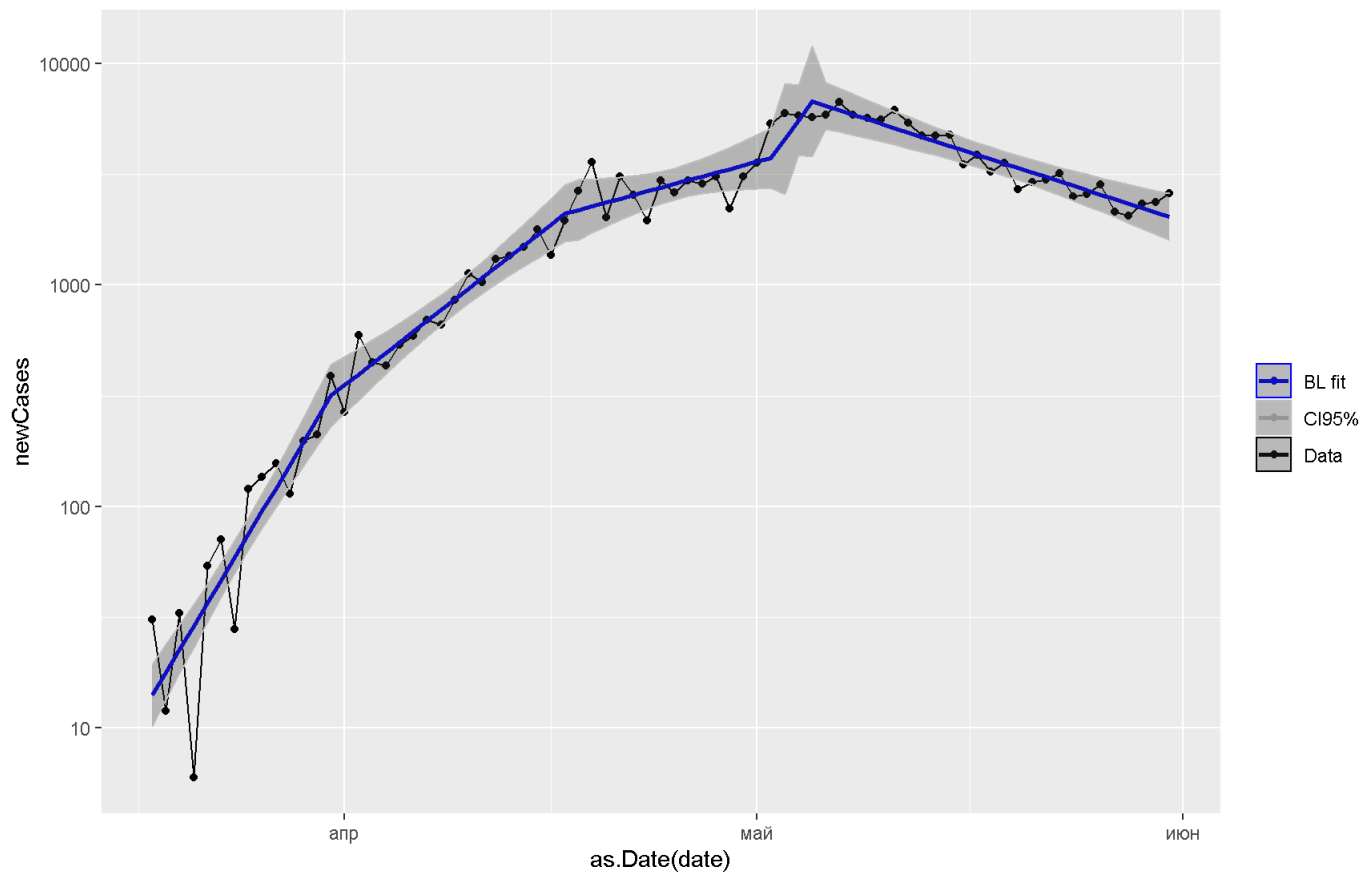

New daily COVID cases in Moscow (npsi=1)
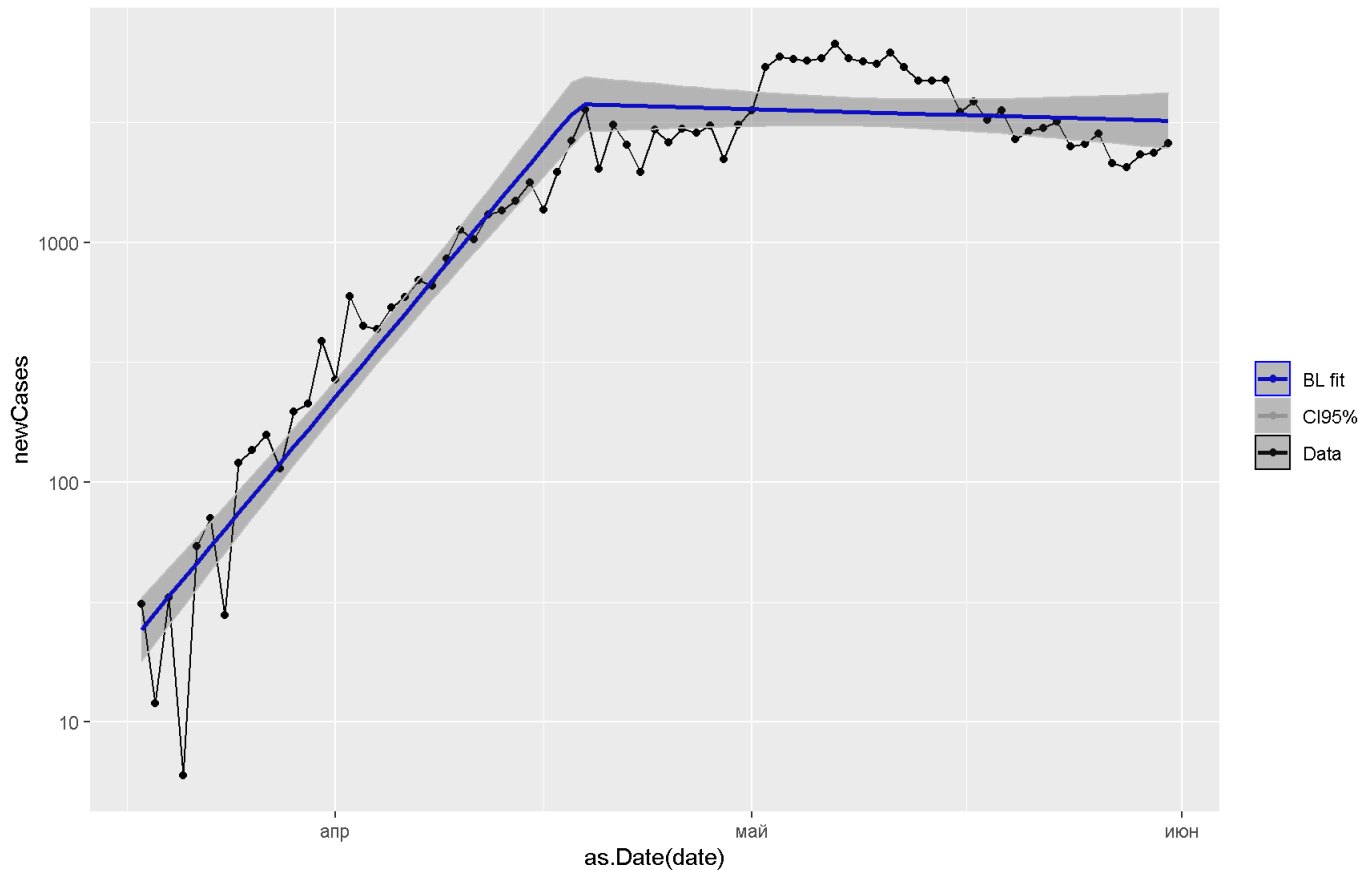
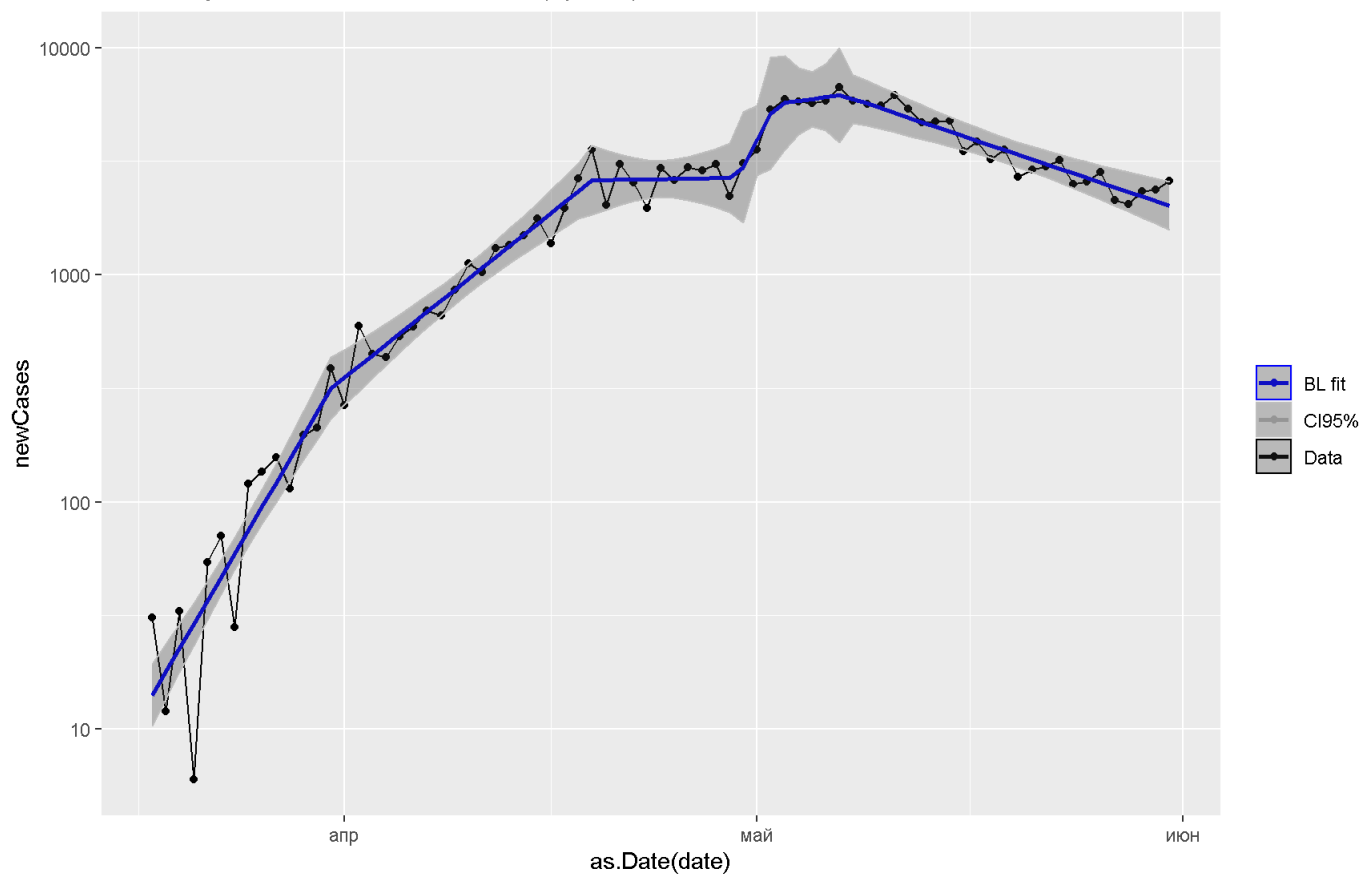New daily COVID cases in Moscow (npsi=2)
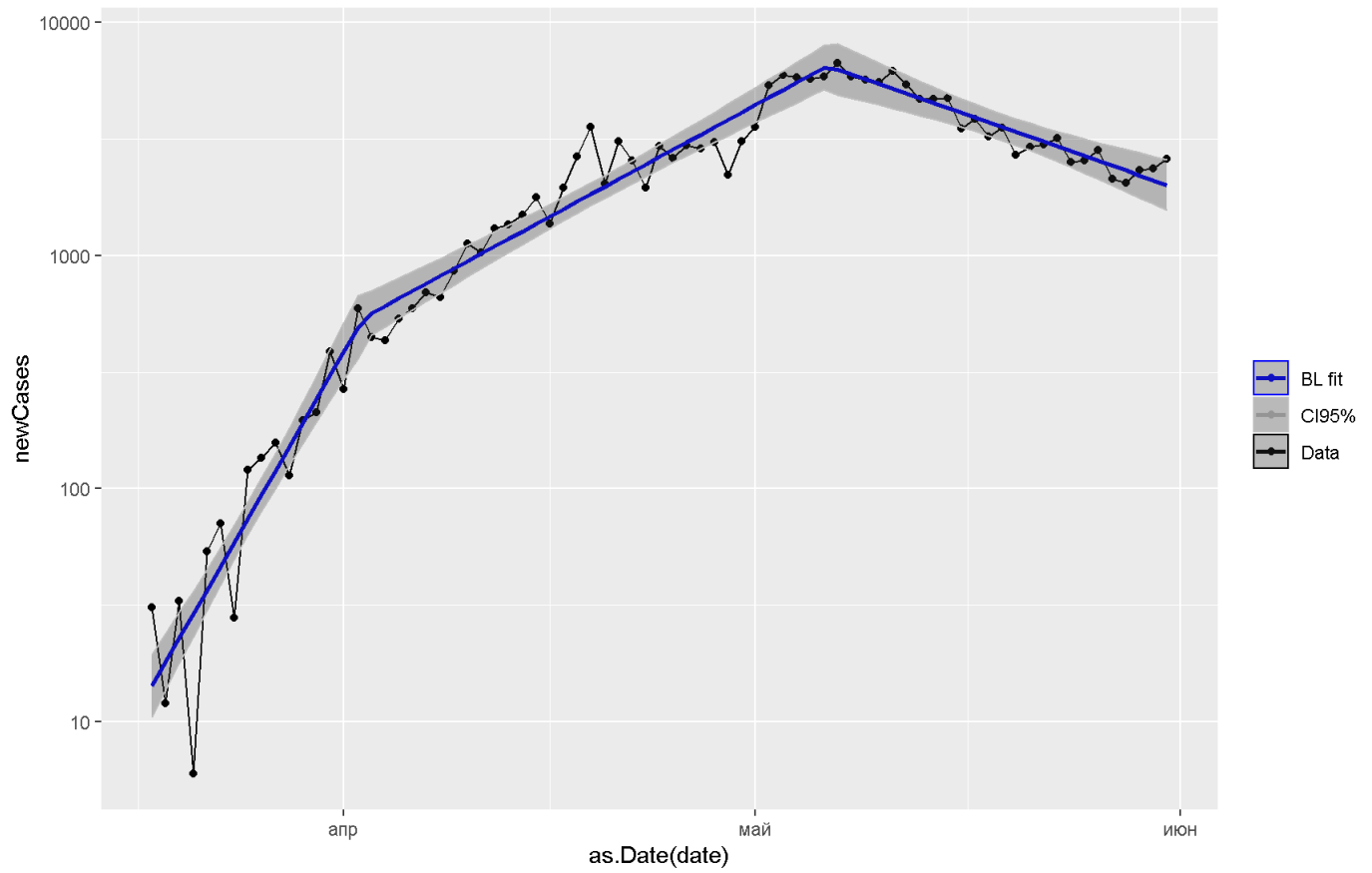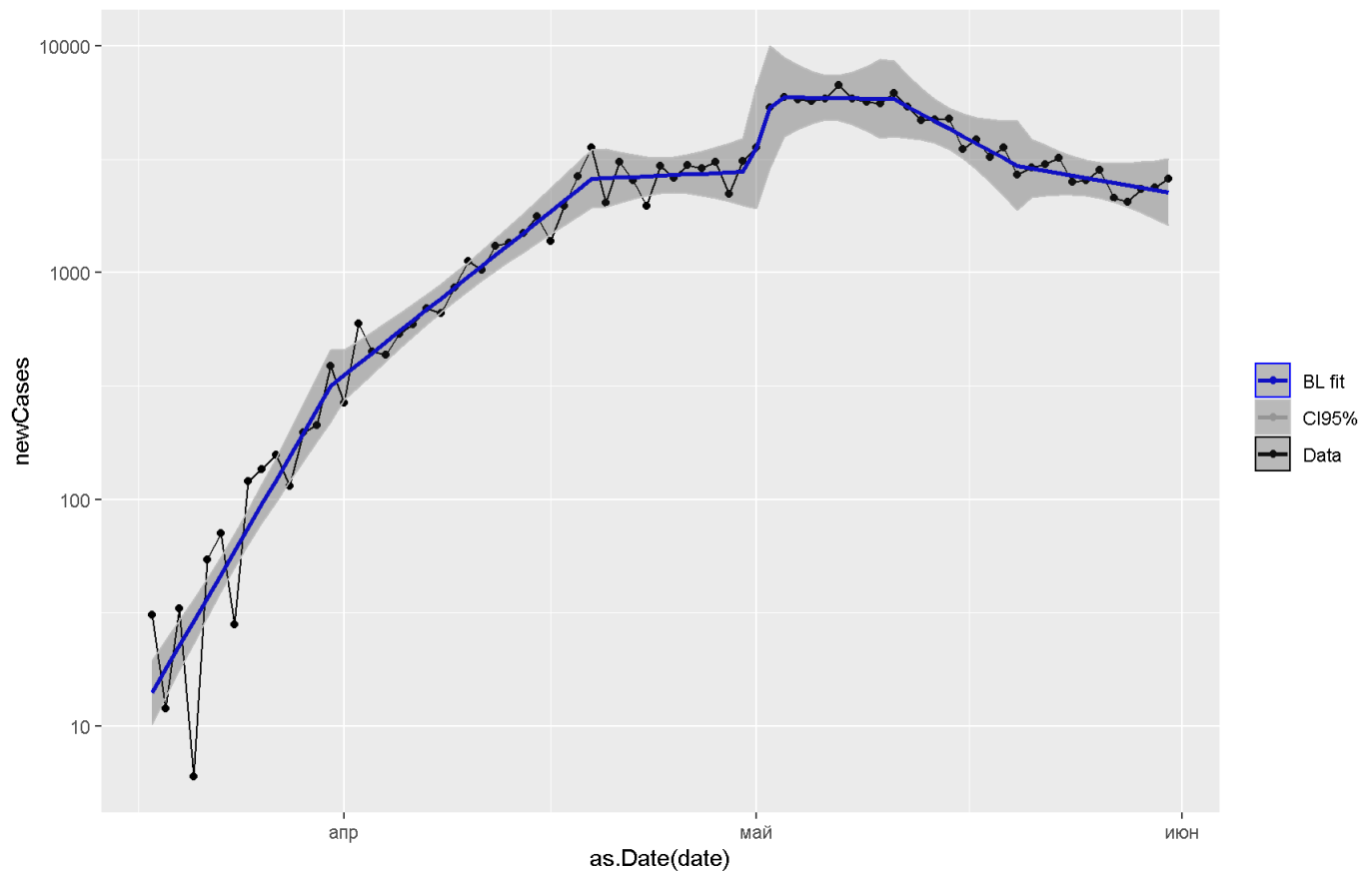
New daily COVID cases in Moscow (npsi=3)

New daily COVID cases in Moscow (npsi=4)
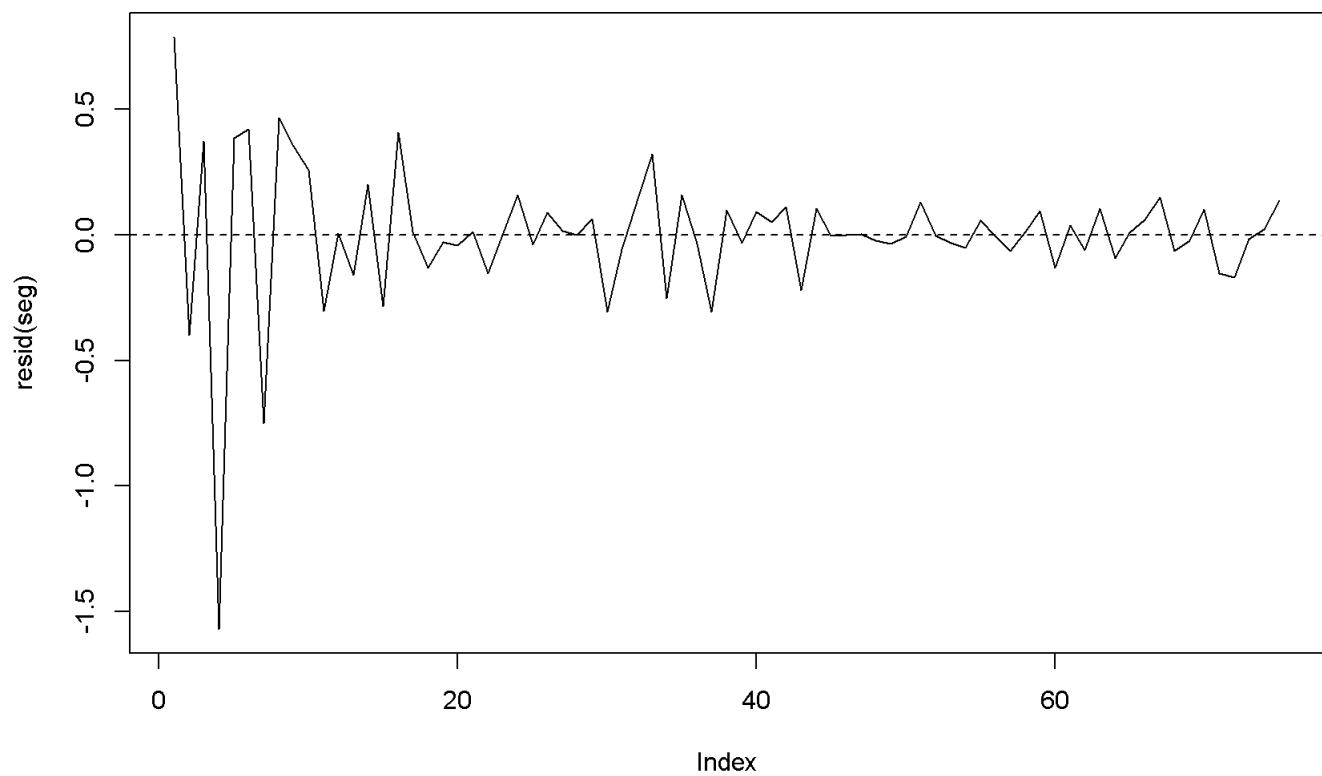

New daily COVID cases in Moscow (npsi=5)

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  0.1595800 0.0083645 19.07800  0.142900 0.1762600
## slope2 -0.0037765 0.0053687 -0.70342 -0.014481 0.0069284
```

```
##
## Doubling of cases:
##      slope1      slope2
##    4.343572 -183.542216
##
## -------------- N. Breaking points = 2 =-------------
## Slopes
## $days_from_beg
##              Est.    St.Err.  t value CI(95%).l CI(95%).u
## slope1  0.236090 0.0175510 13.4510   0.201070   0.271100
## slope2  0.073471 0.0056573 12.9870   0.062185   0.084757
## slope3 -0.047493 0.0089759 -5.2911  -0.065399  -0.029586
##
## Doubling of cases:
##      slope1      slope2      slope3
##    2.935945    9.434296  -14.594723
##
## -------------- N. Breaking points = 3 =-------------
## Slopes
## $days_from_beg
##              Est.    St.Err.  t value CI(95%).l CI(95%).u
## slope1  0.239280 0.0208550 11.4730   0.197650   0.280900
## slope2  0.112210 0.0208550  5.3806   0.070586   0.153840
## slope3  0.056000 0.0098881  5.6634   0.036263   0.075737
## slope4 -0.046853 0.0092759 -5.0511  -0.065368  -0.028339
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4
##    2.896804    6.177232   12.377628  -14.794083
##
## -------------- N. Breaking points = 4 =-------------
## Slopes
## $days_from_beg
##              Est.    St.Err.   t value   CI(95%).l CI(95%).u
## slope1  0.239520 0.0208510 11.48700   0.1978800   0.281160
## slope2  0.111300 0.0155700  7.14850   0.0802070   0.142400
## slope3  0.038579 0.0187950  2.05260   0.0010425   0.076115
## slope4  0.195290 0.2223900  0.87815  -0.2488500   0.639420
## slope5 -0.046080 0.0082238 -5.60330  -0.0625040  -0.029656
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5
##    2.893901    6.227737   17.966956    3.549322  -15.042257
##
## -------------- N. Breaking points = 5 =-------------
## Slopes
## $days_from_beg
##               Est.    St.Err.    t value CI(95%).l CI(95%).u
## slope1  0.2394000 0.0204190 11.724000   0.198600   0.280200
## slope2  0.1111100 0.0139920  7.941200   0.083152   0.139070
## slope3  0.0023568 0.0293650  0.080261  -0.056324   0.061038
## slope4  0.2742800 0.2177700  1.259400  -0.160910   0.709460
## slope5  0.0191410 0.0973920  0.196540  -0.175480   0.213760
## slope6 -0.0471460 0.0090818 -5.191300  -0.065295  -0.028998
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5      slope6
##    2.895352    6.238387 294.105219    2.527152   36.212694  -14.702142
##
## -------------- N. Breaking points = 6 =-------------
## Slopes
## $days_from_beg
##               Est.    St.Err.   t value CI(95%).l CI(95%).u
## slope1  0.2394600 0.022977 10.422000   0.193520 0.2854100
## slope2  0.1104600 0.012989  8.503800   0.084484 0.1364300
## slope3  0.0065973 0.025923  0.254500  -0.045239 0.0584330
## slope4  0.4051400 0.438380  0.924170  -0.471450 1.2817000
## slope5 -0.0023867 0.047831 -0.049898  -0.098030 0.0932570
## slope6 -0.0753560 0.040018 -1.883000  -0.155380 0.0046656
## slope7 -0.0243980 0.025936 -0.940710  -0.076261 0.0274640
##
## Doubling of cases:
##      slope1      slope2      slope3      slope4      slope5      slope6
```

```
##     slope1     slope2     slope3     slope4     slope5     slope6
## 2.894626   6.275097 105.065281   1.710883 -290.420740  -9.198301
##    slope7
## -28.410000
```
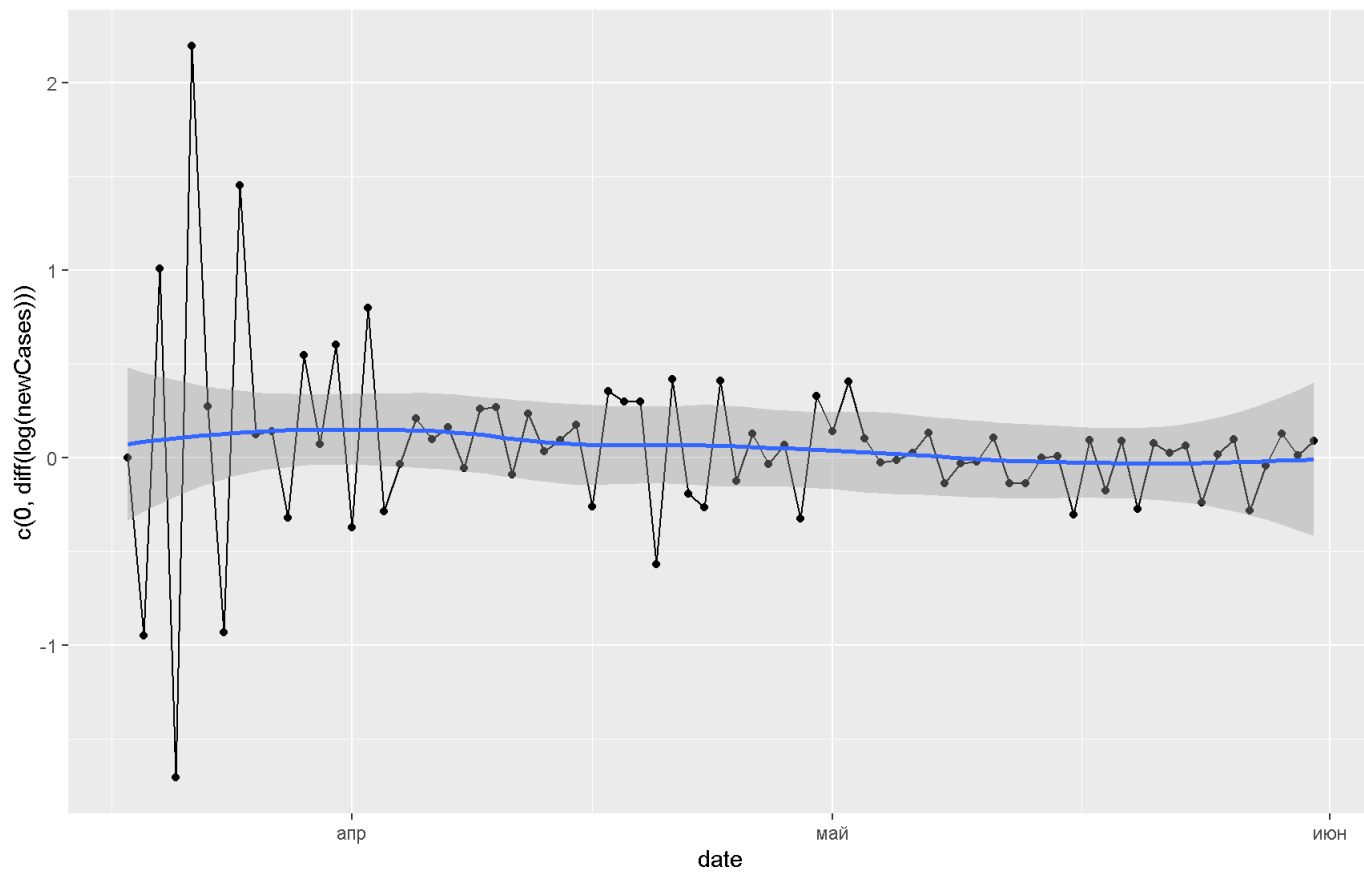
Struct change

```
##
##   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:
## 0.09333333 0.44 0.6
```
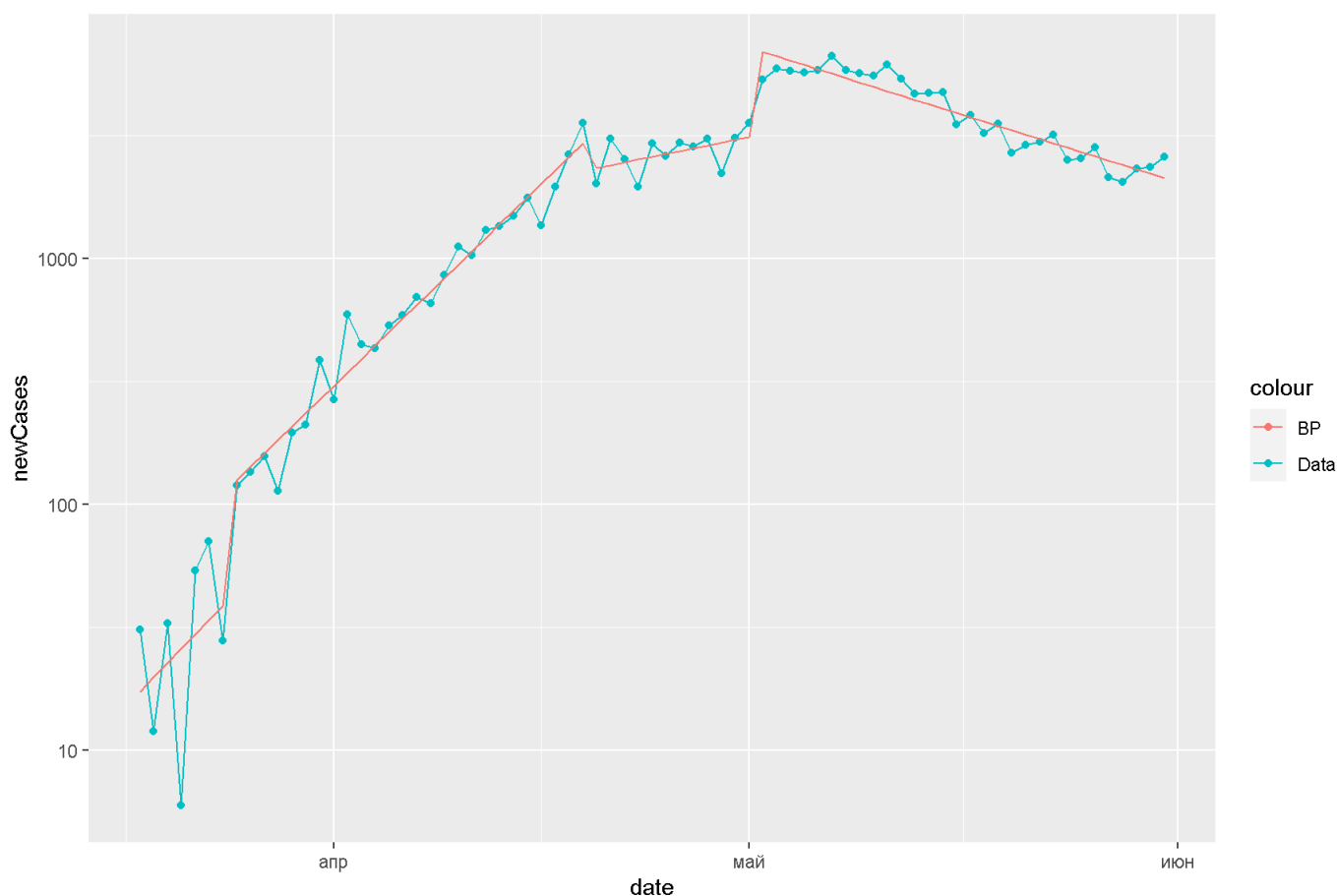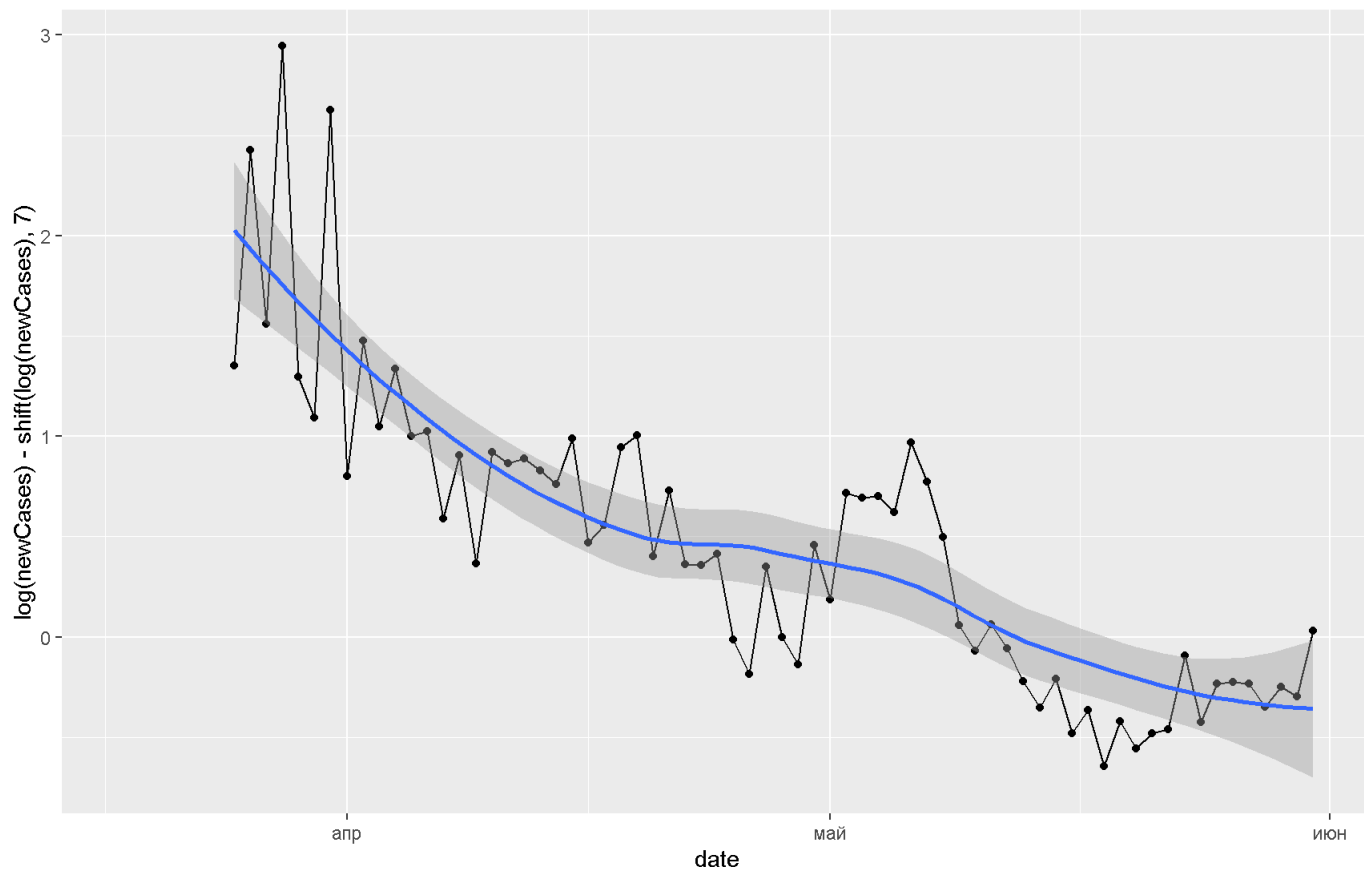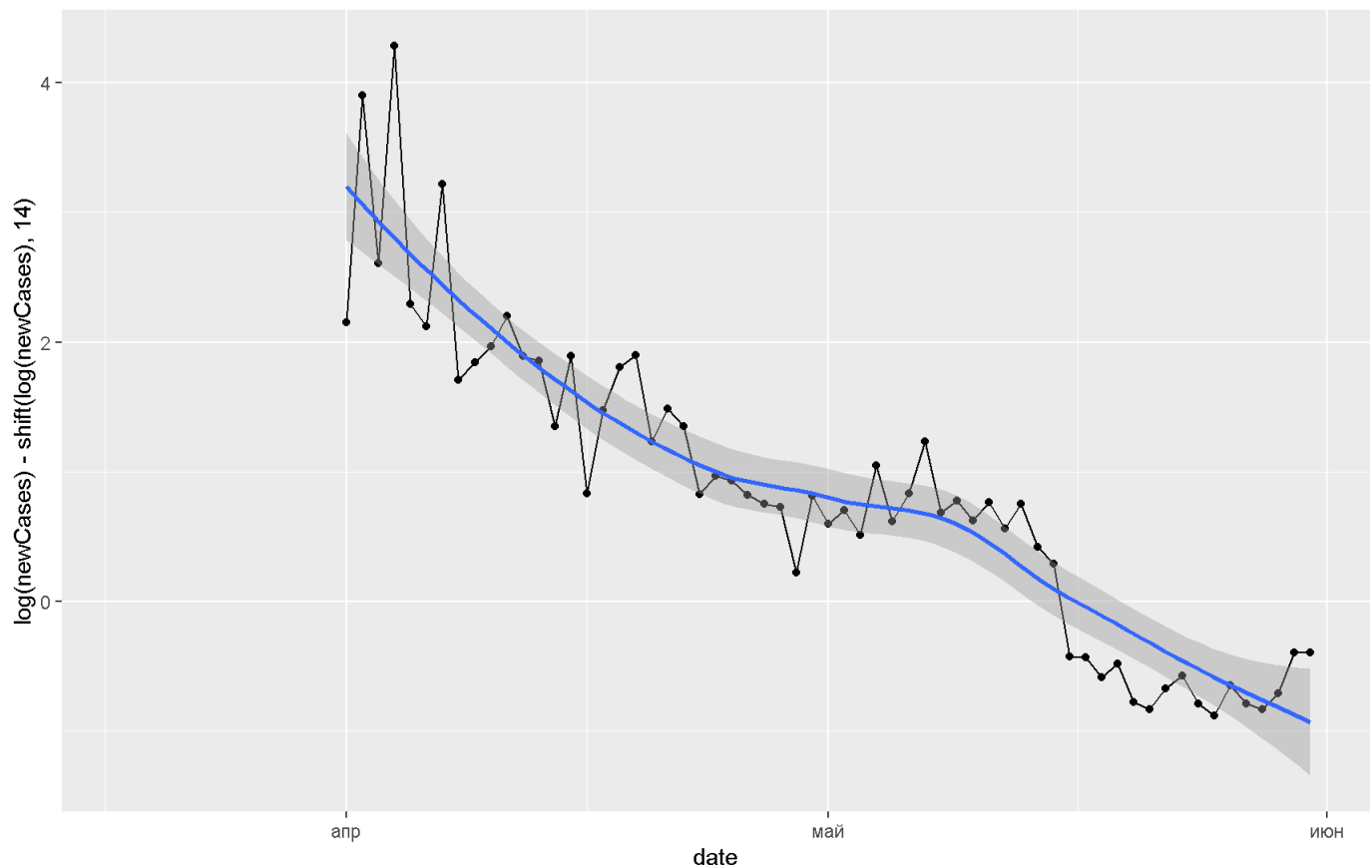

Дифференциалы

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
##       0.0379
## s.e.  0.0291
##
## sigma^2 estimated as 0.05171:  log likelihood=4.23
## AIC=-4.46   AICc=-4.25   BIC=-0.27
##
## Training set error measures:
##                        ME      RMSE       MAE        MPE      MAPE      MASE
## Training set 8.289548e-05 0.2236428 0.1664577 0.02941686 2.201469 0.9667602
##                     ACF1
## Training set -0.2954424
```

ARIMA residuals
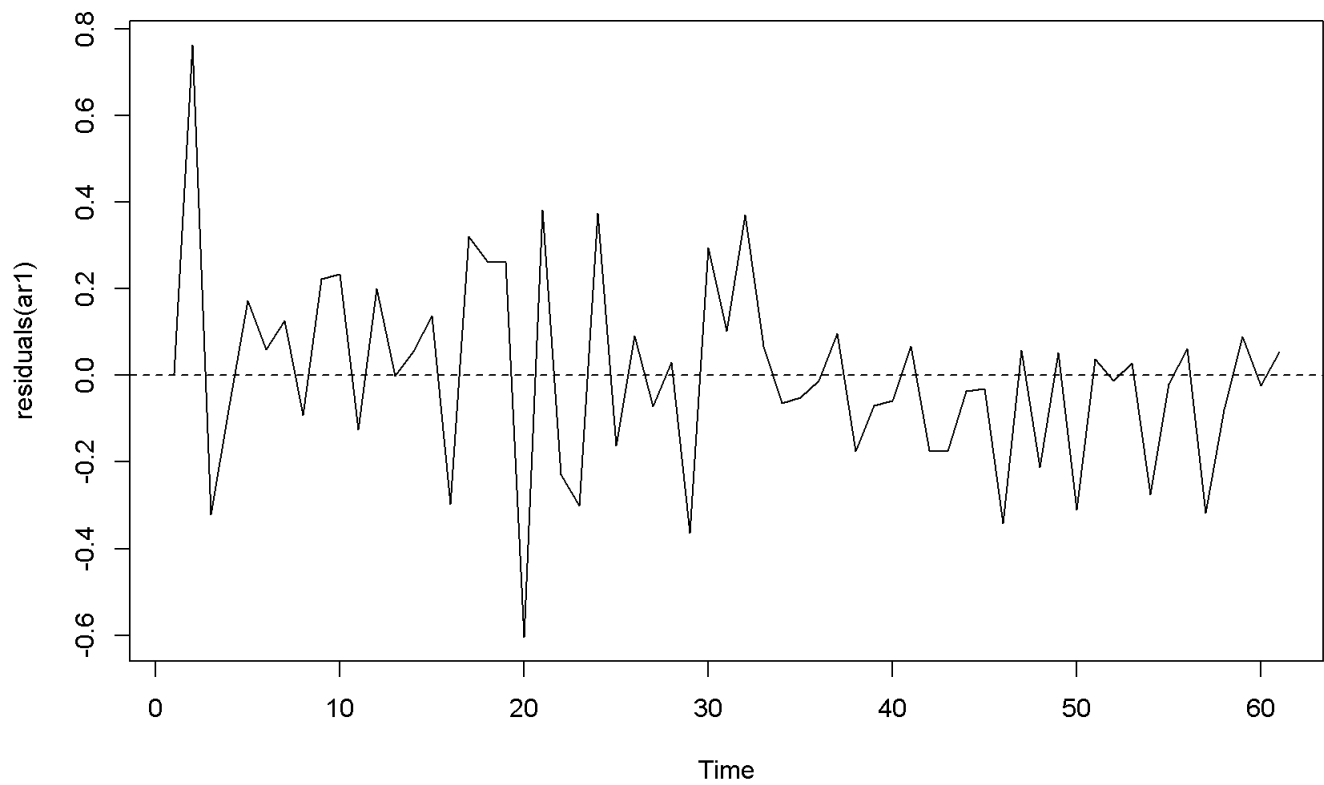
Apple mobility trends

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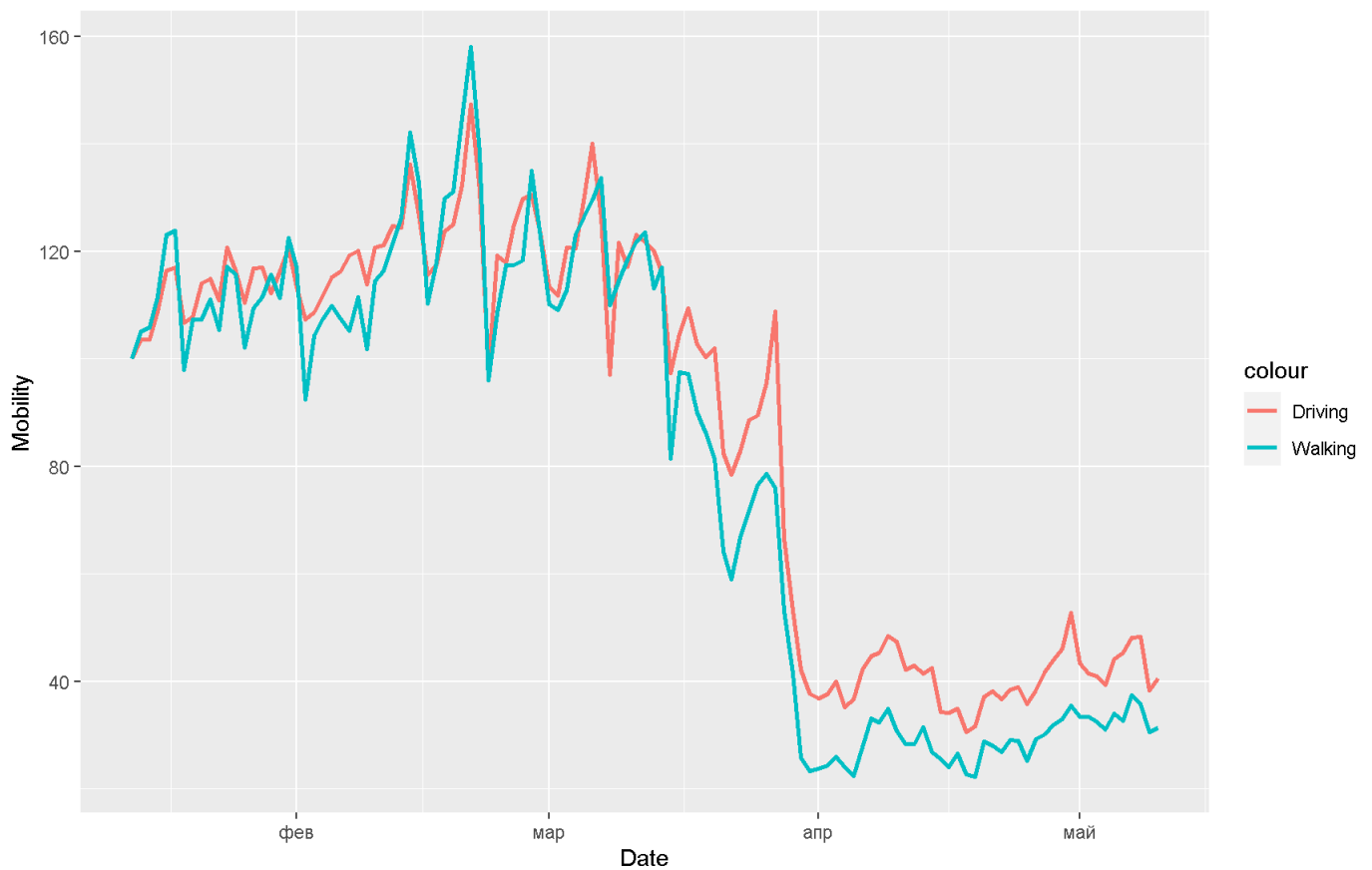
Apple Mobility Trends Report (Moscow) +
COVID new cases growth rate

Rolling sum over 2 weeks (aka active cases)

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