

PM_BAdata.R

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#PM и бронхиальная астма. Анализ больших данных (СГМ ЦГЭ РТ + ЕГИАС МЗ РТ).2014-2020 гг. #

#Л.М.Фатхутдинова#

#1 декабря 2021 года#

```
library(MASS)
```

```
library(ggplot2)
```

```
library(knitr)
```

```
library(psych)
```

```
##
```

```
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
```

```
##
```

```
##      %+%, alpha
```

```
library(Hmisc)
```

```
## Loading required package: lattice
```

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

```
##
```

```
## Attaching package: 'Hmisc'
```

```
## The following object is masked from 'package:psych':
```

```
##
```

```
##      describe
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      format.pval, units
```

```
library(ggpubr)
```

```
library(Rmisc)
```

```
## Loading required package: plyr
```

```
##
```

```
## Attaching package: 'plyr'
```

```
## The following object is masked from 'package:ggpubr':
```

```
##
```

```
##      mutate
```

```

## The following objects are masked from 'package:Hmisc':
##
##   is.discrete, summarize

library(tidyverse)

## -- Attaching packages ----- tidyverse 1.3.1
##
## v tibble  3.1.6      v dplyr   1.0.7
## v tidyr   1.1.4      v stringr 1.4.0
## v readr   2.1.1      v forcats 0.5.1
## v purrr   0.3.4

## -- Conflicts ----- tidyverse_conflicts()
##
## x psych::%+%( )      masks ggplot2::%+%( )
## x psych::alpha( )    masks ggplot2::alpha( )
## x dplyr::arrange( )   masks plyr::arrange( )
## x purrr::compact( )  masks plyr::compact( )
## x dplyr::count( )    masks plyr::count( )
## x dplyr::failwith( ) masks plyr::failwith( )
## x dplyr::filter( )   masks stats::filter( )
## x dplyr::id( )        masks plyr::id( )
## x dplyr::lag( )       masks stats::lag( )
## x dplyr::mutate( )    masks plyr::mutate( ), ggpubr::mutate( )
## x dplyr::rename( )    masks plyr::rename( )
## x dplyr::select( )    masks MASS::select( )
## x dplyr::src( )       masks Hmisc::src( )
## x dplyr::summarise( ) masks plyr::summarise( )
## x dplyr::summarize( ) masks plyr::summarize( ), Hmisc::summarize( )

library(GGally)

## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg      ggplot2

library(car)

## Loading required package: carData

##
## Attaching package: 'car'

## The following object is masked from 'package:dplyr':
##
##   recode

## The following object is masked from 'package:purrr':
##
##   some

```

```
## The following object is masked from 'package:psych':  
##  
##     logit  
  
library(rstatix)  
  
##  
## Attaching package: 'rstatix'  
  
## The following objects are masked from 'package:plyr':  
##  
##     desc, mutate  
  
## The following object is masked from 'package:MASS':  
##  
##     select  
  
## The following object is masked from 'package:stats':  
##  
##     filter  
  
library(ez)  
library(emmeans)  
  
##  
## Attaching package: 'emmeans'  
  
## The following object is masked from 'package:GGally':  
##  
##     pigs  
  
library(ROCR)  
library(sjmisc)  
  
##  
## Attaching package: 'sjmisc'  
  
## The following object is masked from 'package:purrr':  
##  
##     is_empty  
  
## The following object is masked from 'package:tidyr':  
##  
##     replace_na  
  
## The following object is masked from 'package:tibble':  
##  
##     add_case  
  
## The following object is masked from 'package:Hmisc':  
##  
##     %nin%  
  
library(interplot)  
  
## Loading required package: abind
```

```
## Loading required package: arm
## Loading required package: Matrix
##
## Attaching package: 'Matrix'
## The following objects are masked from 'package:tidyr':
##
##     expand, pack, unpack
## Loading required package: lme4
##
## arm (Version 1.12-2, built: 2021-10-15)
## Working directory is C:/Users/liliy/OneDrive/Наука_общая/гранты/РФФИ Микрочас
тицы/РМ точки мониторинга/Статанализ
##
## Attaching package: 'arm'
## The following object is masked from 'package:car':
##
##     logit
## The following objects are masked from 'package:psych':
##
##     logit, rescale, sim
library(survival)
library(survminer)
##
## Attaching package: 'survminer'
## The following object is masked from 'package:survival':
##
##     myeloma
library(lme4)
library(dplyr)
library(sjstats)
##
## Attaching package: 'sjstats'
## The following object is masked from 'package:psych':
##
##     phi
library(cowplot)
##
## Attaching package: 'cowplot'
```

```

## The following object is masked from 'package:ggpubr':
##
##      get_legend

library(nlme)

##
## Attaching package: 'nlme'

## The following object is masked from 'package:lme4':
##
##      lmList

## The following object is masked from 'package:dplyr':
##
##      collapse

library(robustlmm)
library(performance)

##
## Attaching package: 'performance'

## The following objects are masked from 'package:sjstats':
##
##      icc, r2

## The following object is masked from 'package:arm':
##
##      display

## The following object is masked from 'package:ROCR':
##
##      performance

library(rmarkdown)

theme_set(theme_bw())
Sys.setenv(LANG = "en")

##Загрузка файлов с данными##

BAdata <- read.csv('BA_Years.csv', header=TRUE, sep=';', dec = ",")
colSums(is.na(BAdata))

##      year      BA      J45.0      J45.1      J45.8      PopKzn      PopKzn1860
##      0         0         0         0         0         0         0
##      BAAR      J45.0AR      J45.1AR      J45.8AR
##      0         0         0         0

summary(BAdata)

##      year      BA      J45.0      J45.1      J45.8
## Min.   :2014   Min.   :1272   Min.   : 454   Min.   : 14.0   Min.   : 874
## 1st Qu.:2016   1st Qu.:3180   1st Qu.:1474   1st Qu.:242.5   1st Qu.:1867

```

```
## Median :2017 Median :4275 Median :1759 Median :364.0 Median :2668
## Mean :2017 Mean :4193 Mean :1909 Mean :370.0 Mean :2553
## 3rd Qu.:2018 3rd Qu.:4714 3rd Qu.:2034 3rd Qu.:431.0 3rd Qu.:2938
## Max. :2020 Max. :8014 Max. :4137 Max. :865.0 Max. :4717
## PopKzn PopKzn1860 BAAR J45.0AR
## Min. :1190850 Min. :816038 Min. :0.1523 Min. :0.03812
## 1st Qu.:1211308 1st Qu.:824693 1st Qu.:0.3815 1st Qu.:0.11926
## Median :1231878 Median :830057 Median :0.5239 Median :0.14454
## Mean :1228315 Mean :828381 Mean :0.5074 Mean :0.15430
## 3rd Qu.:1247735 3rd Qu.:833476 3rd Qu.:0.5691 3rd Qu.:0.16425
## Max. :1257391 Max. :836237 Max. :0.9744 Max. :0.33044
## J45.1AR J45.8AR
## Min. :0.001677 Min. :0.07339
## 1st Qu.:0.029104 1st Qu.:0.15402
## Median :0.044606 Median :0.21219
## Mean :0.044818 Mean :0.20642
## 3rd Qu.:0.052032 3rd Qu.:0.23730
## Max. :0.105172 Max. :0.37677
```

```
PMdata <- read.csv('PMdata4.csv', header=TRUE, sep=';', dec = ",")
PMdata$year <- as.factor(PMdata$year)
PMdata$code <- as.factor(PMdata$code)
```

```
colSums(is.na(PMdata))
```

```
## code year TSPAavr TSPMax TSP95. PM.10Aavr
## 0 0 12 12 12 12
## PM.10Max PM.1095. PM.2.5Aavr PM.2.5Max PM.2.595. J45.0
## 12 12 12 12 12 0
## J45.1 J45.8 BA Pop CountJ450 CountJ451
## 0 0 0 0 0 0
## CountJ458 CountJBA HeadLogAavr TBLogAavr PLogAavr TBPLogAavr
## 0 0 7 7 7 7
## TotalLogAavr HeadAavr TBAavr PAavr TBP Aavr TotalAavr
## 7 7 10 14 14 14
## HeadLogMax TBLogMax PLogMax TBPLogMax TotalLogMax HeadMax
## 16 16 16 16 16 16
## TBMax PMax TBPMax TotalMax
## 16 16 16 16
```

```
#data <- data[!is.na(data$PM2.5),]
```

```
length(unique(PMdata$code))
```

```
## [1] 15
```

```
table(PMdata$code)
```

```
##
```

```
## 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
## 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
```

```
table(PMdata$year)
```

```
##
## 2014 2015 2016 2017 2018 2019 2020
##   15   15   15   15   15   15   15

with(PMdata, table(year, code))

##          code
## year    1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
## 2014 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2015 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2016 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2017 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2018 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2019 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2020 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

summary(PMdata)

##          code      year      TSPAвр      TSPMax      TSP95.
## 1          : 7    2014:15    Min.    :0.0529    Min.    :0.1400    Min.    :0.0810
## 2          : 7    2015:15    1st Qu.:0.1031    1st Qu.:0.3600    1st Qu.:0.2570
## 3          : 7    2016:15    Median :0.1245    Median :0.5210    Median :0.3070
## 4          : 7    2017:15    Mean    :0.1297    Mean    :0.4977    Mean    :0.3152
## 5          : 7    2018:15    3rd Qu.:0.1556    3rd Qu.:0.6370    3rd Qu.:0.3690
## 6          : 7    2019:15    Max.    :0.2239    Max.    :0.7690    Max.    :0.6930
## (Other):63    2020:15    NA's    :12      NA's    :12      NA's    :12
##      PM.10Avr      PM.10Max      PM.1095.      PM.2.5Avr
## Min.    :0.02140    Min.    :0.0590    Min.    :0.0510    Min.    :0.00000
## 1st Qu.:0.04630    1st Qu.:0.1940    1st Qu.:0.1450    1st Qu.:0.00860
## Median :0.06160    Median :0.2480    Median :0.1830    Median :0.02070
## Mean    :0.06582    Mean    :0.2665    Mean    :0.1816    Mean    :0.02041
## 3rd Qu.:0.08420    3rd Qu.:0.3480    3rd Qu.:0.2240    3rd Qu.:0.02670
## Max.    :0.11920    Max.    :0.4530    Max.    :0.3870    Max.    :0.08420
## NA's    :12      NA's    :12      NA's    :12      NA's    :12
##      PM.2.5Max      PM.2.595.      J45.0      J45.1
## Min.    :0.000    Min.    :0.00000    Min.    :0.0000    Min.    :0.00000
## 1st Qu.:0.105    1st Qu.:0.04600    1st Qu.:0.2404    1st Qu.:0.00000
## Median :0.127    Median :0.10400    Median :0.4152    Median :0.06626
## Mean    :0.137    Mean    :0.08558    Mean    :0.5793    Mean    :0.11263
## 3rd Qu.:0.171    3rd Qu.:0.11600    3rd Qu.:0.7546    3rd Qu.:0.13584
## Max.    :0.420    Max.    :0.23000    Max.    :3.1821    Max.    :0.74873
## NA's    :12      NA's    :12
##      J45.8      BA      Pop      CountJ450
## Min.    :0.0000    Min.    :0.0000    Min.    : 294    Min.    : 0.00
## 1st Qu.:0.3646    1st Qu.:0.6551    1st Qu.:1540    1st Qu.: 6.00
## Median :0.6010    Median :1.0208    Median :3131    Median :15.00
## Mean    :0.8081    Mean    :1.3617    Mean    :4152    Mean    :20.46
## 3rd Qu.:1.0427    3rd Qu.:1.6897    3rd Qu.:7289    3rd Qu.:28.00
## Max.    :5.0539    Max.    :7.8616    Max.    :9574    Max.    :83.00
##
##      CountJ451      CountJ458      CountJBA      HeadLogAvr
## Min.    : 0.000    Min.    : 0.00    Min.    : 0.00    Min.    :0.01022
## 1st Qu.: 0.000    1st Qu.: 11.00    1st Qu.: 18.00    1st Qu.:0.02255
```

```
## Median : 2.000 Median : 21.00 Median : 34.00 Median :0.03219
## Mean : 3.448 Mean : 29.95 Mean : 48.22 Mean :0.03802
## 3rd Qu.: 6.000 3rd Qu.: 37.00 3rd Qu.: 68.00 3rd Qu.:0.04306
## Max. :16.000 Max. :188.00 Max. :233.00 Max. :0.15995
## NA's :7
## TBlogAvr PLogAvr TBPLogAvr TotalLogAvr
## Min. :0.000125 Min. :0.000000 Min. :0.000143 Min. :0.01410
## 1st Qu.:0.001092 1st Qu.:0.001383 1st Qu.:0.002486 1st Qu.:0.02712
## Median :0.001676 Median :0.002002 Median :0.003686 Median :0.03878
## Mean :0.002361 Mean :0.002877 Mean :0.005243 Mean :0.04687
## 3rd Qu.:0.002518 3rd Qu.:0.003126 3rd Qu.:0.005592 3rd Qu.:0.05219
## Max. :0.011148 Max. :0.015286 Max. :0.026434 Max. :0.20241
## NA's :7 NA's :7 NA's :7 NA's :7
## HeadAvr TBAvr PAvr TBPAvr
## Min. :0.01356 Min. :0.000100 Min. :0.000000 Min. :0.000100
## 1st Qu.:0.02978 1st Qu.:0.000506 1st Qu.:0.000572 1st Qu.:0.001037
## Median :0.04071 Median :0.000908 Median :0.001337 Median :0.002386
## Mean :0.05131 Mean :0.001359 Mean :0.002027 Mean :0.003405
## 3rd Qu.:0.05538 3rd Qu.:0.001416 3rd Qu.:0.002149 3rd Qu.:0.003588
## Max. :0.21858 Max. :0.007929 Max. :0.012701 Max. :0.020630
## NA's :7 NA's :10 NA's :14 NA's :14
## TotalAvr HeadLogMax TBlogMax PLogMax
## Min. :0.01365 Min. :0.009298 Min. :0.000784 Min. :0.000135
## 1st Qu.:0.03136 1st Qu.:0.055442 1st Qu.:0.005233 1st Qu.:0.004570
## Median :0.04234 Median :0.081587 Median :0.007370 Median :0.009550
## Mean :0.05545 Mean :0.082690 Mean :0.007179 Mean :0.009179
## 3rd Qu.:0.05805 3rd Qu.:0.117317 3rd Qu.:0.009543 3rd Qu.:0.012600
## Max. :0.23920 Max. :0.175006 Max. :0.017069 Max. :0.019580
## NA's :14 NA's :16 NA's :16 NA's :16
## TBPLogMax TotalLogMax HeadMax TBMax
## Min. :0.000949 Min. :0.01386 Min. :0.01811 Min. :0.000493
## 1st Qu.:0.008826 1st Qu.:0.07921 1st Qu.:0.10138 1st Qu.:0.002410
## Median :0.017008 Median :0.10831 Median :0.13046 Median :0.004793
## Mean :0.016359 Mean :0.11004 Mean :0.13165 Mean :0.004795
## 3rd Qu.:0.021786 3rd Qu.:0.15875 3rd Qu.:0.18774 3rd Qu.:0.006170
## Max. :0.036462 Max. :0.21740 Max. :0.25212 Max. :0.010320
## NA's :16 NA's :16 NA's :16 NA's :16
## PMax TBPMMax TotalMax
## Min. :0.000000 Min. :0.000512 Min. :0.02035
## 1st Qu.:0.004225 1st Qu.:0.006624 1st Qu.:0.10845
## Median :0.007800 Median :0.012595 Median :0.14401
## Mean :0.007685 Mean :0.012483 Mean :0.14413
## 3rd Qu.:0.010067 3rd Qu.:0.016237 3rd Qu.:0.20528
## Max. :0.017301 Max. :0.027621 Max. :0.27491
## NA's :16 NA's :16 NA's :16
```

```
PMdataComplete <- read.csv('PMdata5.csv', header=TRUE, sep=';', dec = ",")
PMdataComplete$year <- as.factor(PMdataComplete$year)
PMdataComplete$code <- as.factor(PMdataComplete$code)
```

```
colSums(is.na(PMdataComplete))
```



```
##      code      year      TSPAvr      TSPMax      TSP95.      PM.10Avr
##      0          0          0          0          0          0
##      PM.10Max    PM.1095.    PM.2.5Avr    PM.2.5Max    PM.2.595.    J45.0
##      0          0          0          0          0          0
##      J45.1      J45.8      BA          Pop      CountJ450    CountJ451
##      0          0          0          0          0          0
##      CountJ458    CountJBA    HeadLogAvr    TBLogAvr    PLogAvr    TBPLogAvr
##      0          0          2          2          2          2
##      TotalLogAvr    HeadAvr      TBAvr      PAvr      TBPAvr      TotalAvr
##      2          2          2          2          2          2
##      HeadLogMax    TBLogMax    PLogMax    TBPLogMax    TotalLogMax    HeadMax
##      4          4          4          4          4          4
##      TBMax      PMax      TBPMax    TotalMax
##      4          4          4          4
```

```
length(unique(PMdataComplete$code))
```

```
## [1] 15
```

```
table(PMdataComplete$code)
```

```
##
##  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15
##  7  3  5  7  7  7  3  7  7  7  7  7  7  7  5
```

```
table(PMdataComplete$year)
```

```
##
## 2014 2015 2016 2017 2018 2019 2020
##   14   14   15   13   13   12   12
```

```
with(PMdataComplete, table(year, code))
```

```
##      code
## year  1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
## 2014 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
## 2015 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0
## 2016 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
## 2017 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1
## 2018 1 0 1 1 1 1 0 1 1 1 1 1 1 1 1
## 2019 1 0 0 1 1 1 0 1 1 1 1 1 1 1 1
## 2020 1 0 0 1 1 1 0 1 1 1 1 1 1 1 1
```

```
summary(PMdataComplete)
```

```
##      code      year      TSPAvr      TSPMax      TSP95.
##  1      : 7    2014:14    Min.    :0.0529    Min.    :0.1400    Min.    :0.0810
##  4      : 7    2015:14    1st Qu.:0.1031    1st Qu.:0.3600    1st Qu.:0.2570
##  5      : 7    2016:15    Median :0.1245    Median :0.5210    Median :0.3070
##  6      : 7    2017:13    Mean    :0.1297    Mean    :0.4977    Mean    :0.3152
##  8      : 7    2018:13    3rd Qu.:0.1556    3rd Qu.:0.6370    3rd Qu.:0.3690
##  9      : 7    2019:12    Max.    :0.2239    Max.    :0.7690    Max.    :0.6930
## (Other):51    2020:12
##      PM.10Avr      PM.10Max      PM.1095.      PM.2.5Avr
```

```

## Min. :0.02140 Min. :0.0590 Min. :0.0510 Min. :0.00000
## 1st Qu.:0.04630 1st Qu.:0.1940 1st Qu.:0.1450 1st Qu.:0.00860
## Median :0.06160 Median :0.2480 Median :0.1830 Median :0.02070
## Mean :0.06582 Mean :0.2665 Mean :0.1816 Mean :0.02041
## 3rd Qu.:0.08420 3rd Qu.:0.3480 3rd Qu.:0.2240 3rd Qu.:0.02670
## Max. :0.11920 Max. :0.4530 Max. :0.3870 Max. :0.08420
##
## PM.2.5Max PM.2.595. J45.0 J45.1
## Min. :0.000 Min. :0.00000 Min. :0.0000 Min. :0.00000
## 1st Qu.:0.105 1st Qu.:0.04600 1st Qu.:0.2404 1st Qu.:0.00000
## Median :0.127 Median :0.10400 Median :0.4368 Median :0.06495
## Mean :0.137 Mean :0.08558 Mean :0.5989 Mean :0.11635
## 3rd Qu.:0.171 3rd Qu.:0.11600 3rd Qu.:0.7546 3rd Qu.:0.13782
## Max. :0.420 Max. :0.23000 Max. :3.1821 Max. :0.74873
##
## J45.8 BA Pop CountJ450
## Min. :0.0000 Min. :0.0000 Min. : 294 Min. : 0.00
## 1st Qu.:0.3646 1st Qu.:0.6707 1st Qu.:1540 1st Qu.: 5.00
## Median :0.6371 Median :1.0210 Median :3018 Median :14.00
## Mean :0.8455 Mean :1.4261 Mean :3939 Mean :19.59
## 3rd Qu.:1.0919 3rd Qu.:1.8185 3rd Qu.:7289 3rd Qu.:27.00
## Max. :5.0539 Max. :7.8616 Max. :9574 Max. :83.00
##
## CountJ451 CountJ458 CountJBA HeadLogAvr
## Min. : 0.00 Min. : 0.0 Min. : 0.00 Min. :0.01022
## 1st Qu.: 0.00 1st Qu.: 11.0 1st Qu.: 17.00 1st Qu.:0.02256
## Median : 2.00 Median : 21.0 Median : 31.00 Median :0.03081
## Mean : 3.28 Mean : 29.6 Mean : 47.35 Mean :0.03829
## 3rd Qu.: 5.00 3rd Qu.: 36.0 3rd Qu.: 62.00 3rd Qu.:0.04400
## Max. :16.00 Max. :188.0 Max. :233.00 Max. :0.15995
## NA's :2
##
## TBLogAvr PLogAvr TBPLogAvr TotalLogAvr
## Min. :0.000125 Min. :0.000000 Min. :0.000143 Min. :0.01410
## 1st Qu.:0.001106 1st Qu.:0.001388 1st Qu.:0.002522 1st Qu.:0.02714
## Median :0.001701 Median :0.002004 Median :0.003706 Median :0.03769
## Mean :0.002428 Mean :0.002960 Mean :0.005392 Mean :0.04739
## 3rd Qu.:0.002547 3rd Qu.:0.003124 3rd Qu.:0.005710 3rd Qu.:0.05304
## Max. :0.011148 Max. :0.015286 Max. :0.026434 Max. :0.20241
## NA's :2 NA's :2 NA's :2 NA's :2
##
## HeadAvr TBAvr PAvr TBPAvr
## Min. :0.01356 Min. :0.0001000 Min. :0.0000000 Min. :0.000100
## 1st Qu.:0.02991 1st Qu.:0.0005065 1st Qu.:0.0005725 1st Qu.:0.001037
## Median :0.03980 Median :0.0009080 Median :0.0013370 Median :0.002386
## Mean :0.05205 Mean :0.0013763 Mean :0.0020273 Mean :0.003405
## 3rd Qu.:0.05533 3rd Qu.:0.0014295 3rd Qu.:0.0021490 3rd Qu.:0.003589
## Max. :0.21858 Max. :0.0079290 Max. :0.0127010 Max. :0.020630
## NA's :2 NA's :2 NA's :2 NA's :2
##
## TotalAvr HeadLogMax TBLogMax PLogMax
## Min. :0.01365 Min. :0.009298 Min. :0.000784 Min. :0.000135
## 1st Qu.:0.03136 1st Qu.:0.055442 1st Qu.:0.005233 1st Qu.:0.004570
## Median :0.04234 Median :0.081587 Median :0.007370 Median :0.009550
## Mean :0.05545 Mean :0.082690 Mean :0.007179 Mean :0.009179

```

```
## 3rd Qu.:0.05805 3rd Qu.:0.117317 3rd Qu.:0.009543 3rd Qu.:0.012600
## Max. :0.23920 Max. :0.175006 Max. :0.017069 Max. :0.019580
## NA's :2 NA's :4 NA's :4 NA's :4
## TBPLogMax TotalLogMax HeadMax TBMax
## Min. :0.000949 Min. :0.01386 Min. :0.01811 Min. :0.000493
## 1st Qu.:0.008826 1st Qu.:0.07921 1st Qu.:0.10138 1st Qu.:0.002410
## Median :0.017008 Median :0.10831 Median :0.13046 Median :0.004793
## Mean :0.016359 Mean :0.11004 Mean :0.13165 Mean :0.004795
## 3rd Qu.:0.021786 3rd Qu.:0.15875 3rd Qu.:0.18774 3rd Qu.:0.006170
## Max. :0.036462 Max. :0.21740 Max. :0.25212 Max. :0.010320
## NA's :4 NA's :4 NA's :4 NA's :4
## PMax TBPMMax TotalMax
## Min. :0.000000 Min. :0.000512 Min. :0.02035
## 1st Qu.:0.004225 1st Qu.:0.006624 1st Qu.:0.10845
## Median :0.007800 Median :0.012595 Median :0.14401
## Mean :0.007685 Mean :0.012483 Mean :0.14413
## 3rd Qu.:0.010067 3rd Qu.:0.016237 3rd Qu.:0.20528
## Max. :0.017301 Max. :0.027621 Max. :0.27491
## NA's :4 NA's :4 NA's :4
```

##Динамика заболеваемости БА по годам##

###В интервале 2014-2020 гг. наблюдался рост первичной заболеваемости (%) - абсолютного риска AR (%) БА###

###Рост заболеваемости БА наблюдался в первую очередь за счет неаллергической и смешанной форм БА###

```
modBAtime <- lm(BAAR ~ year, data = BAdata)
anova(modBAtime)
```

```
## Analysis of Variance Table
```

```
##
```

```
## Response: BAAR
```

```
## Df Sum Sq Mean Sq F value Pr(>F)
```

```
## year 1 0.24044 0.24044 7.7331 0.03886 *
```

```
## Residuals 5 0.15546 0.031092
```

```
## ---
```

```
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(modBAtime)
```

```
##
```

```
## Call:
```

```
## lm(formula = BAAR ~ year, data = BAdata)
```

```
##
```

```
## Residuals:
```

```
## 1 2 3 4 5 6 7
```

```
## -0.077052 -0.007906 0.034117 0.022337 0.008345 0.281674 -0.261515
```

```
##
```

```
## Coefficients:
```

```
## Estimate Std. Error t value Pr(>|t|)
```

```
## (Intercept) -186.40242 67.21318 -2.773 0.0392 *
```

```
## year 0.09267 0.03332 2.781 0.0389 *
```

```
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1763 on 5 degrees of freedom
## Multiple R-squared:  0.6073, Adjusted R-squared:  0.5288
## F-statistic: 7.733 on 1 and 5 DF,  p-value: 0.03886

modBAtime <- glm(BAAR ~ year, data = BAdata, family = 'gaussian')
anova(modBAtime)

## Analysis of Deviance Table
##
## Model: gaussian, link: identity
##
## Response: BAAR
##
## Terms added sequentially (first to last)
##
##          Df Deviance Resid. Df Resid. Dev
## NULL                                6      0.39590
## year   1   0.24044             5      0.15546

summary(modBAtime)

##
## Call:
## glm(formula = BAAR ~ year, family = "gaussian", data = BAdata)
##
## Deviance Residuals:
##          1          2          3          4          5          6          7
## -0.077052 -0.007906  0.034117  0.022337  0.008345  0.281674 -0.261515
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -186.40242    67.21318  -2.773   0.0392 *
## year          0.09267     0.03332   2.781   0.0389 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.03109243)
##
##      Null deviance: 0.39590  on 6  degrees of freedom
## Residual deviance: 0.15546  on 5  degrees of freedom
## AIC: -0.7857
##
## Number of Fisher Scoring iterations: 2

modBAtime <- lm(J45.0AR ~ year, data = BAdata)
anova(modBAtime)

## Analysis of Variance Table
##
## Response: J45.0AR
##          Df    Sum Sq  Mean Sq F value  Pr(>F)
```

```

## year      1 0.022240 0.0222401 4.2844 0.09325 .
## Residuals 5 0.025954 0.0051909
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(modBAtime)

##
## Call:
## lm(formula = J45.0AR ~ year, data = BAdata)
##
## Residuals:
##      1      2      3      4      5      6      7
## -0.0316288  0.0027565  0.0184208 -0.0008779 -0.0074150  0.1197710 -0.1010265
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -56.69107    27.46304   -2.064   0.0939 .
## year         0.02818     0.01362    2.070   0.0933 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.07205 on 5 degrees of freedom
## Multiple R-squared:  0.4615, Adjusted R-squared:  0.3538
## F-statistic: 4.284 on 1 and 5 DF, p-value: 0.09325

modBAtime <- glm(J45.0AR ~ year, data = BAdata, family = 'gaussian')
anova(modBAtime)

## Analysis of Deviance Table
##
## Model: gaussian, link: identity
##
## Response: J45.0AR
##
## Terms added sequentially (first to last)
##
##              Df Deviance Resid. Df Resid. Dev
## NULL              6    0.048195
## year  1    0.02224      5    0.025955

summary(modBAtime)

##
## Call:
## glm(formula = J45.0AR ~ year, family = "gaussian", data = BAdata)
##
## Deviance Residuals:
##      1      2      3      4      5      6      7
## -0.031629  0.002757  0.018421 -0.000878 -0.007415  0.119771 -0.101027
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)

```

```
## (Intercept) -56.69107    27.46304   -2.064    0.0939 .
## year          0.02818     0.01362    2.070    0.0933 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.005190903)
##
##      Null deviance: 0.048195  on 6  degrees of freedom
## Residual deviance: 0.025955  on 5  degrees of freedom
## AIC: -13.316
##
## Number of Fisher Scoring iterations: 2

modBAtime <- lm(J45.1AR ~ year, data = BAdata)
anova(modBAtime)

## Analysis of Variance Table
##
## Response: J45.1AR
##           Df      Sum Sq   Mean Sq F value    Pr(>F)
## year         1 0.0036696 0.0036696    6.669 0.04929 *
## Residuals    5 0.0027513 0.0005503
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(modBAtime)

##
## Call:
## lm(formula = J45.1AR ~ year, data = BAdata)
##
## Residuals:
##          1          2          3          4          5          6          7
## -0.0087972 -0.0043431  0.0072585  0.0020463  0.0009338  0.0374582 -0.0345564
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -23.045941   8.941445  -2.577  0.0496 *
## year         0.011448   0.004433   2.582  0.0493 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.02346 on 5 degrees of freedom
## Multiple R-squared:  0.5715, Adjusted R-squared:  0.4858
## F-statistic: 6.669 on 1 and 5 DF, p-value: 0.04929

modBAtime <- glm(J45.1AR ~ year, data = BAdata, family = 'gaussian')
anova(modBAtime)

## Analysis of Deviance Table
##
## Model: gaussian, link: identity
##
## Response: J45.1AR
```

```
##
## Terms added sequentially (first to last)
##
##
##      Df  Deviance Resid. Df Resid. Dev
## NULL                      6  0.0064209
## year  1 0.0036696          5  0.0027513

summary(modBAtime)

##
## Call:
## glm(formula = J45.1AR ~ year, family = "gaussian", data = BAdata)
##
## Deviance Residuals:
##      1      2      3      4      5      6      7
## -0.008797 -0.004343  0.007258  0.002046  0.000934  0.037458 -0.034556
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -23.045941    8.941445  -2.577  0.0496 *
## year         0.011448    0.004433   2.582  0.0493 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.0005502515)
##
##      Null deviance: 0.0064209  on 6  degrees of freedom
## Residual deviance: 0.0027513  on 5  degrees of freedom
## AIC: -29.026
##
## Number of Fisher Scoring iterations: 2

modBAtime <- lm(J45.8AR ~ year, data = BAdata)
anova(modBAtime)

## Analysis of Variance Table
##
## Response: J45.8AR
##      Df Sum Sq Mean Sq F value Pr(>F)
## year  1 0.034769 0.034769  8.2183 0.03513 *
## Residuals  5 0.021154 0.004231
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(modBAtime)

##
## Call:
## lm(formula = J45.8AR ~ year, data = BAdata)
##
## Residuals:
##      1      2      3      4      5      6      7
## -0.027316 -0.006308  0.007208  0.013727  0.012780  0.099865 -0.099955
```

```
##
## Coefficients:
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept) -70.86976    24.79331  -2.858   0.0355 *
## year         0.03524     0.01229   2.867   0.0351 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.06504 on 5 degrees of freedom
## Multiple R-squared:  0.6217, Adjusted R-squared:  0.5461
## F-statistic: 8.218 on 1 and 5 DF,  p-value: 0.03513

modBAtime <- glm(J45.8AR ~ year, data = BAdat, family = 'gaussian')
anova(modBAtime)

## Analysis of Deviance Table
##
## Model: gaussian, link: identity
##
## Response: J45.8AR
##
## Terms added sequentially (first to last)
##
##
##      Df Deviance Resid. Df Resid. Dev
## NULL                6    0.055923
## year  1 0.034769        5    0.021154

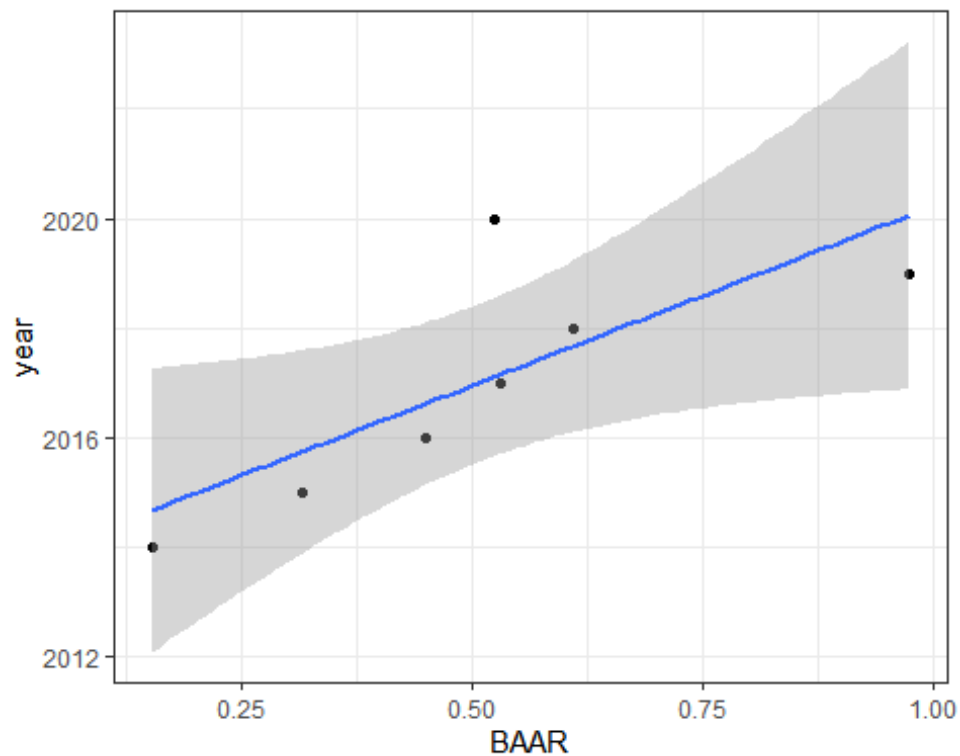
summary(modBAtime)

##
## Call:
## glm(formula = J45.8AR ~ year, family = "gaussian", data = BAdat)
##
## Deviance Residuals:
##      1      2      3      4      5      6      7
## -0.027316 -0.006308  0.007208  0.013727  0.012780  0.099865 -0.099955
##
## Coefficients:
##           Estimate Std. Error t value Pr(>|t|)
## (Intercept) -70.86976    24.79331  -2.858   0.0355 *
## year         0.03524     0.01229   2.867   0.0351 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for gaussian family taken to be 0.004230727)
##
##      Null deviance: 0.055923  on 6  degrees of freedom
## Residual deviance: 0.021154  on 5  degrees of freedom
## AIC: -14.748
##
## Number of Fisher Scoring iterations: 2
```



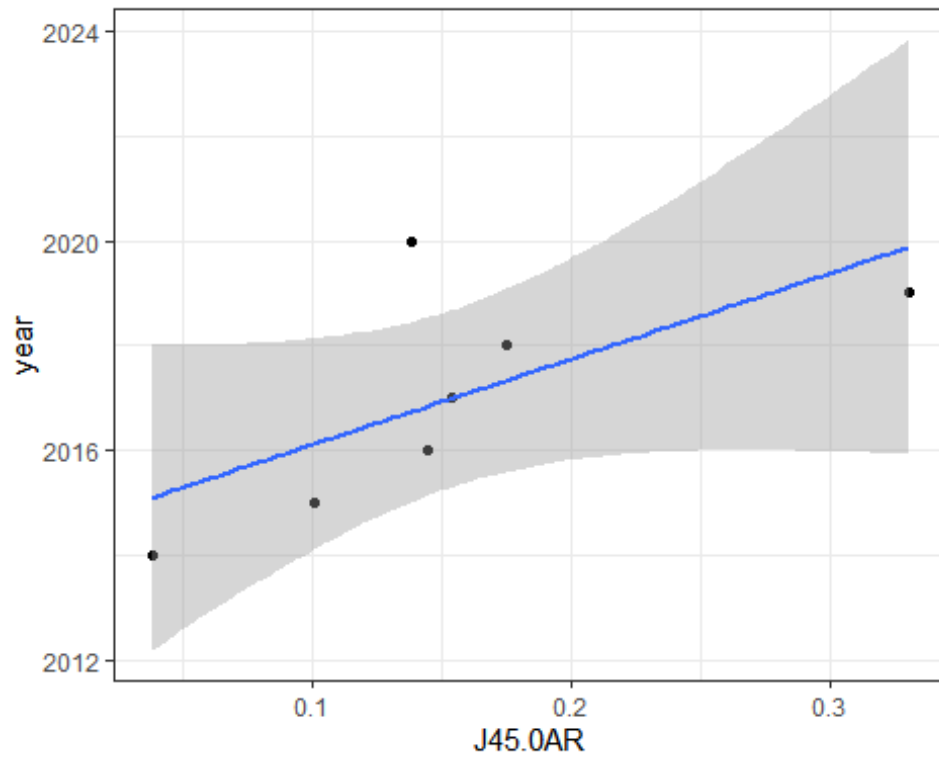
```
ggplot(BAdata, aes(x = BAAR, y = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'
```

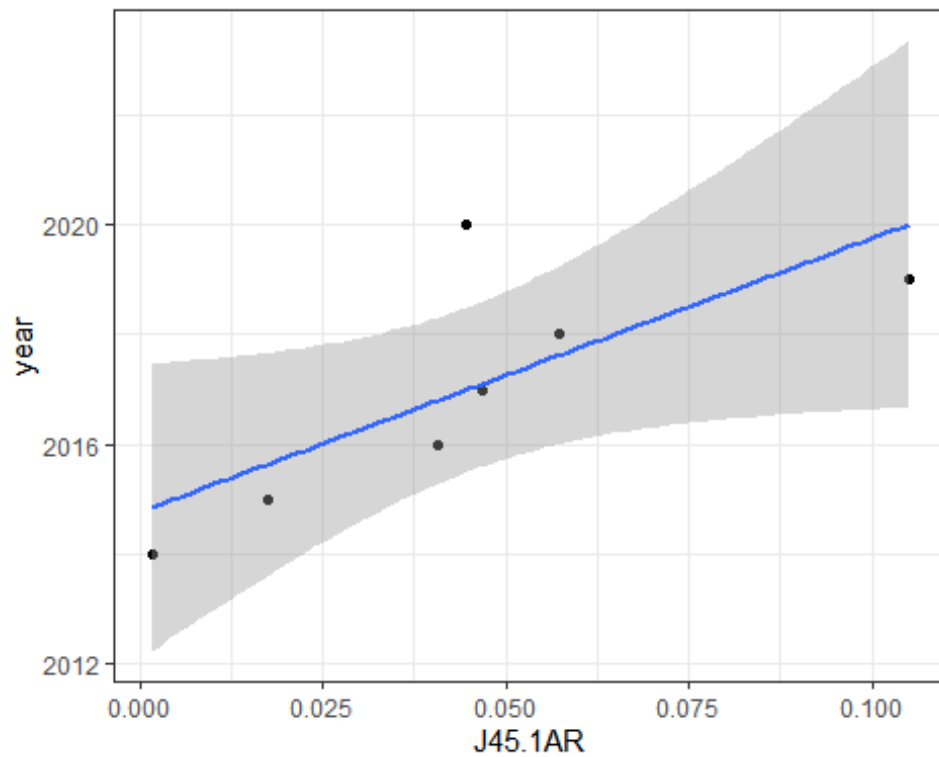


```
ggplot(BAdata, aes(x = J45.0AR, y = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'
```

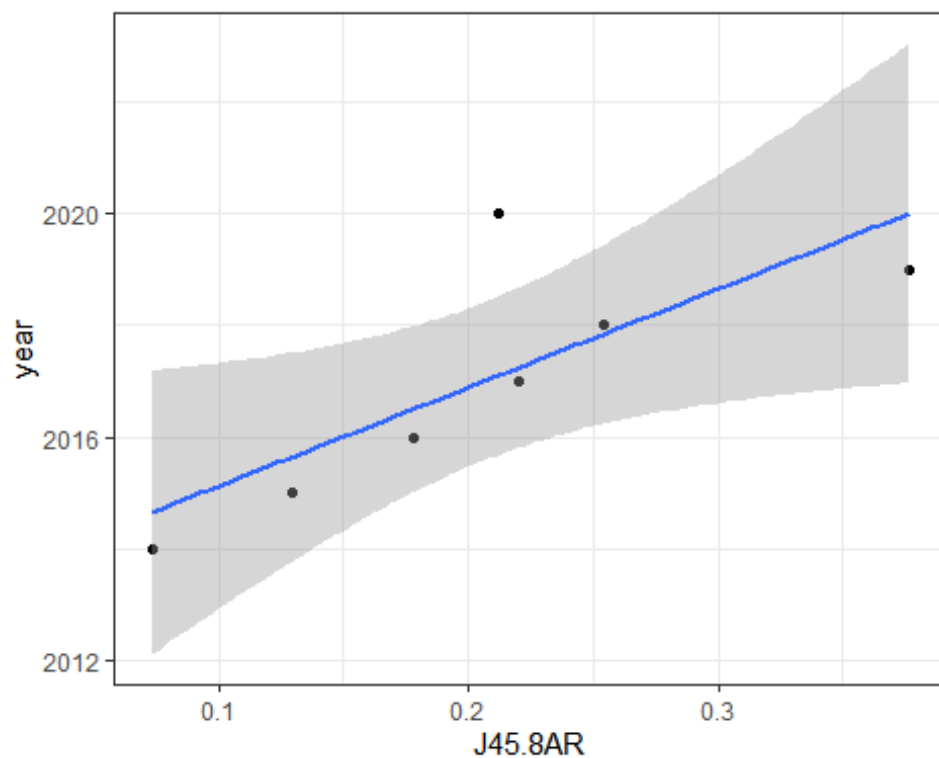


```
ggplot(BAdata, aes(x = J45.1AR, y = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)
## `geom_smooth()` using formula 'y ~ x'
```



```
ggplot(BAdata, aes(x = J45.8AR, y = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

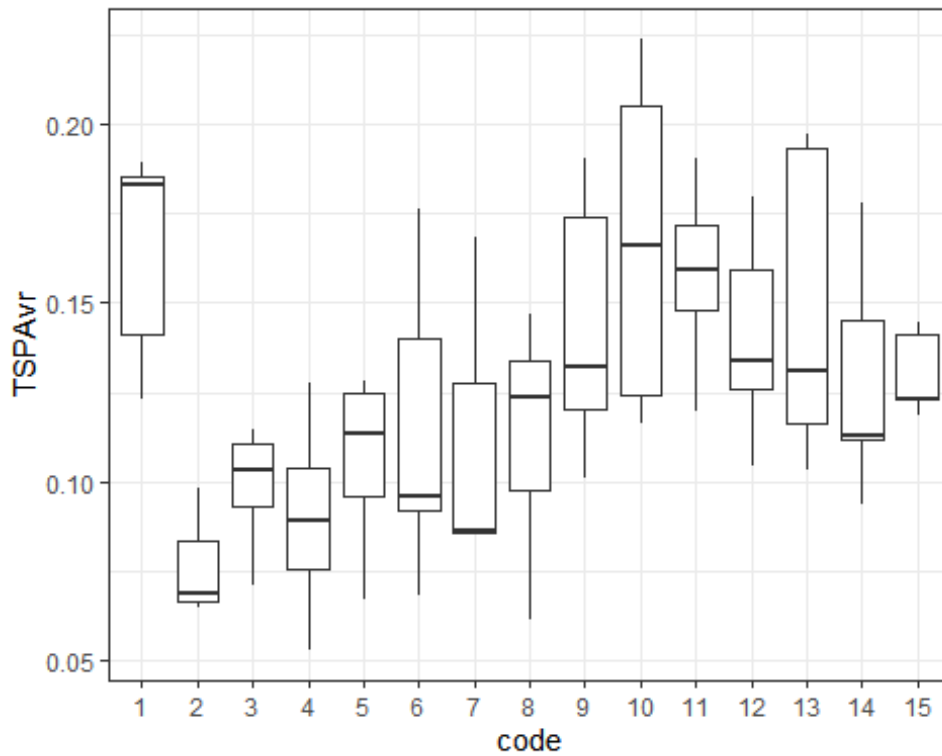
## `geom_smooth()` using formula 'y ~ x'
```



##Визуализация уровней РМ по мониторинговым точкам##

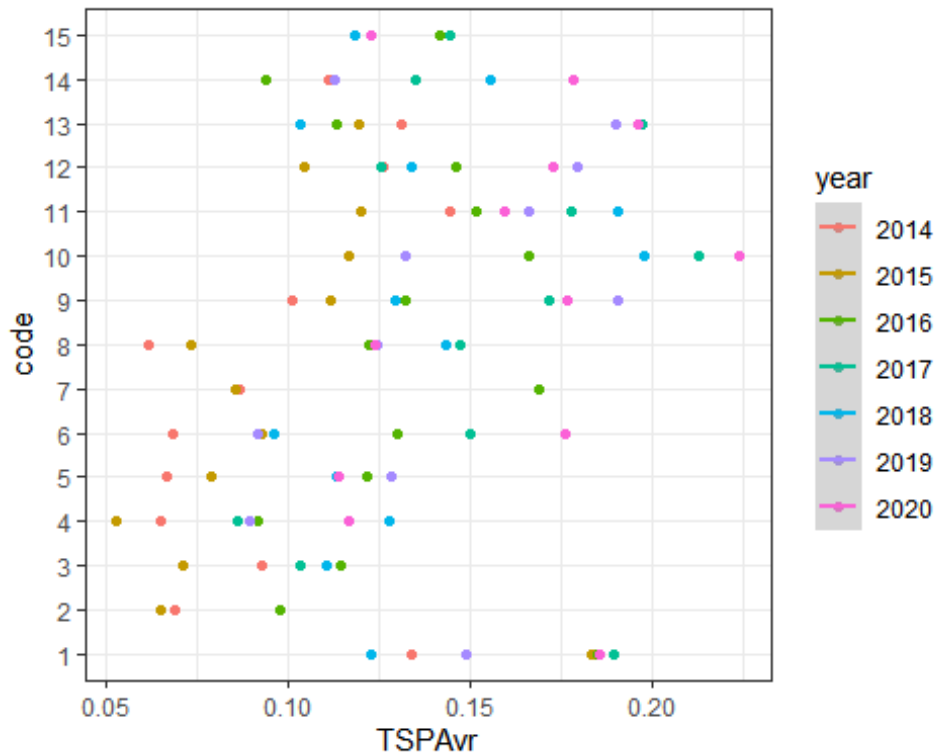
```
ggplot(PMdata, aes(x = code, y = TSPAвр)) + geom_boxplot()

## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = TSPAwr, y = code, color = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 12 rows containing non-finite values (stat_smooth).
## Warning: Removed 12 rows containing missing values (geom_point).
```

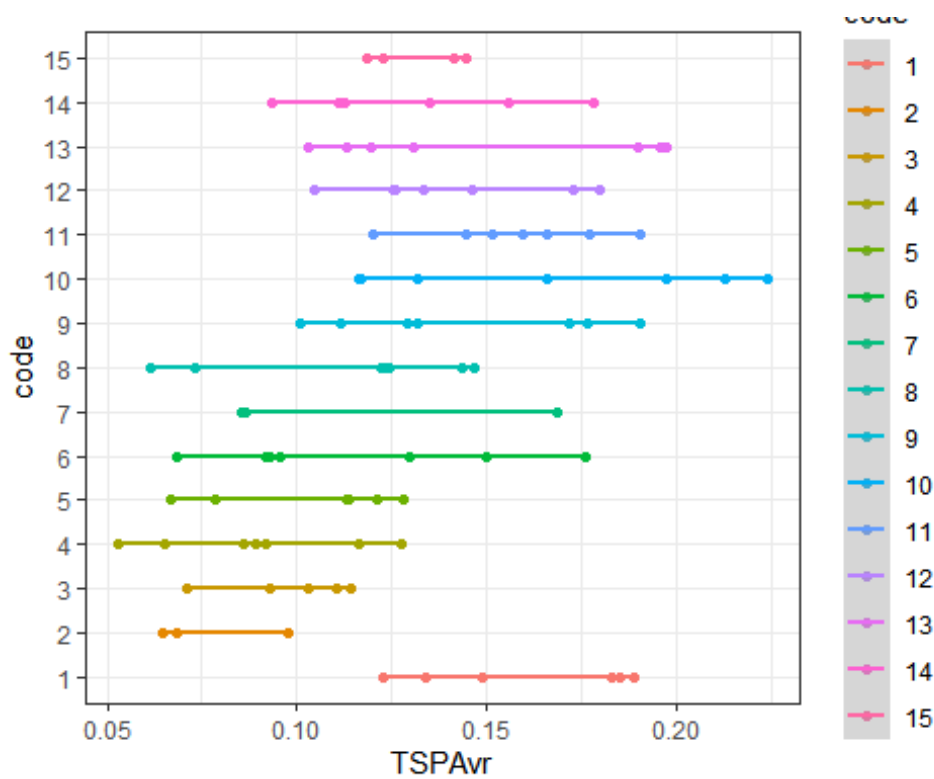


```
ggplot(PMdata, aes(x = TSPAver, y = code, color = code)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

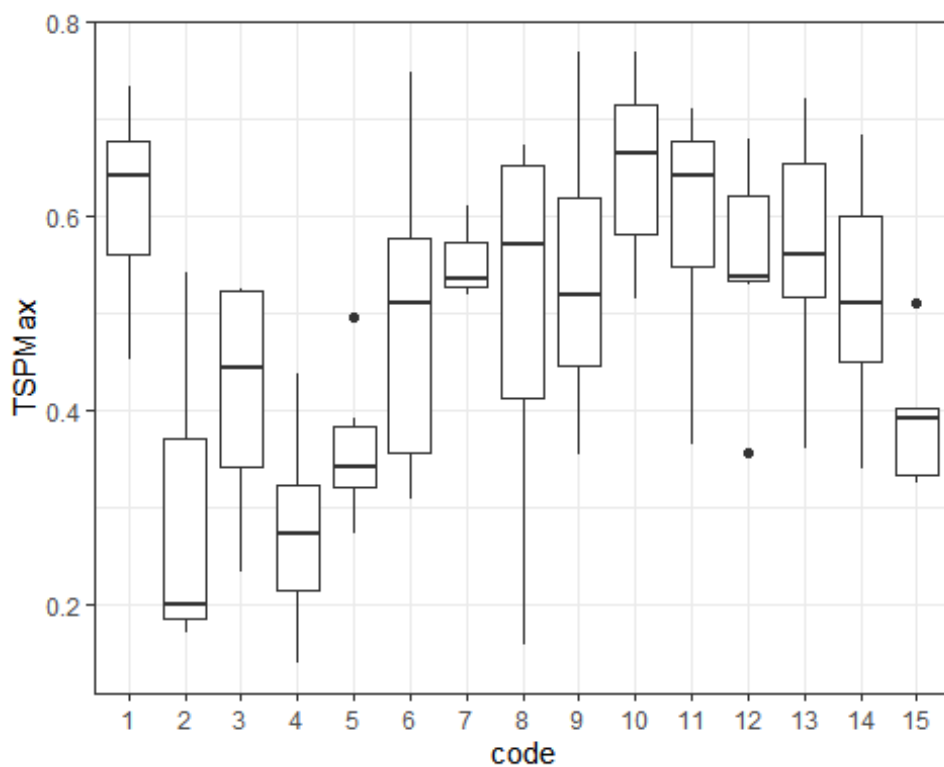
## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```



```
ggplot(PMdata, aes(x = code, y = TSPMax)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

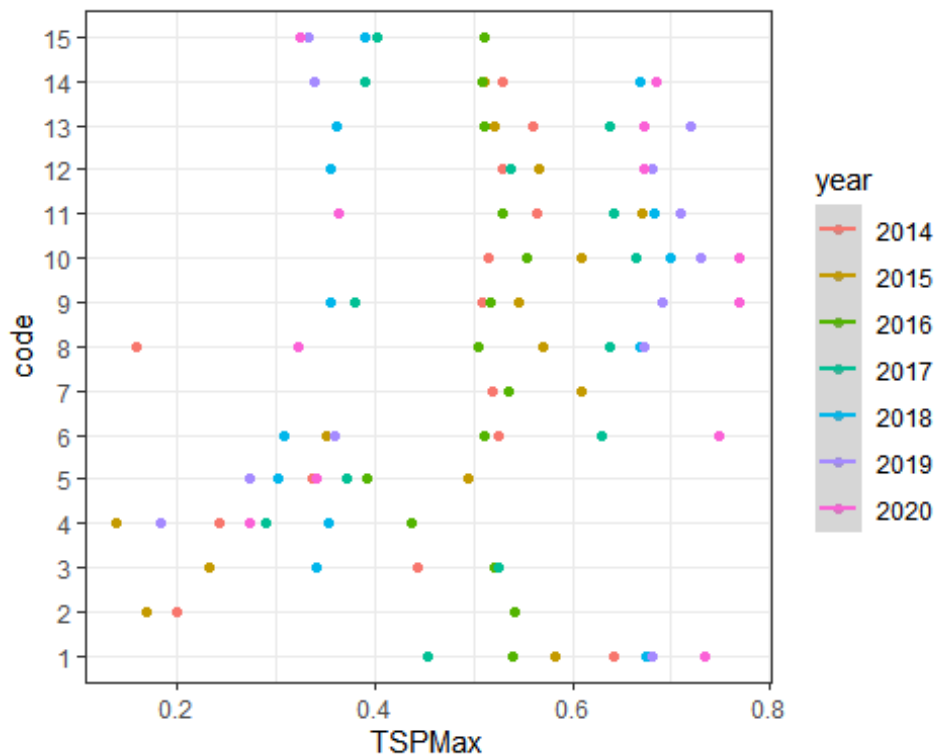


```
ggplot(PMdata, aes(x = TSPMax, y = code, color = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```

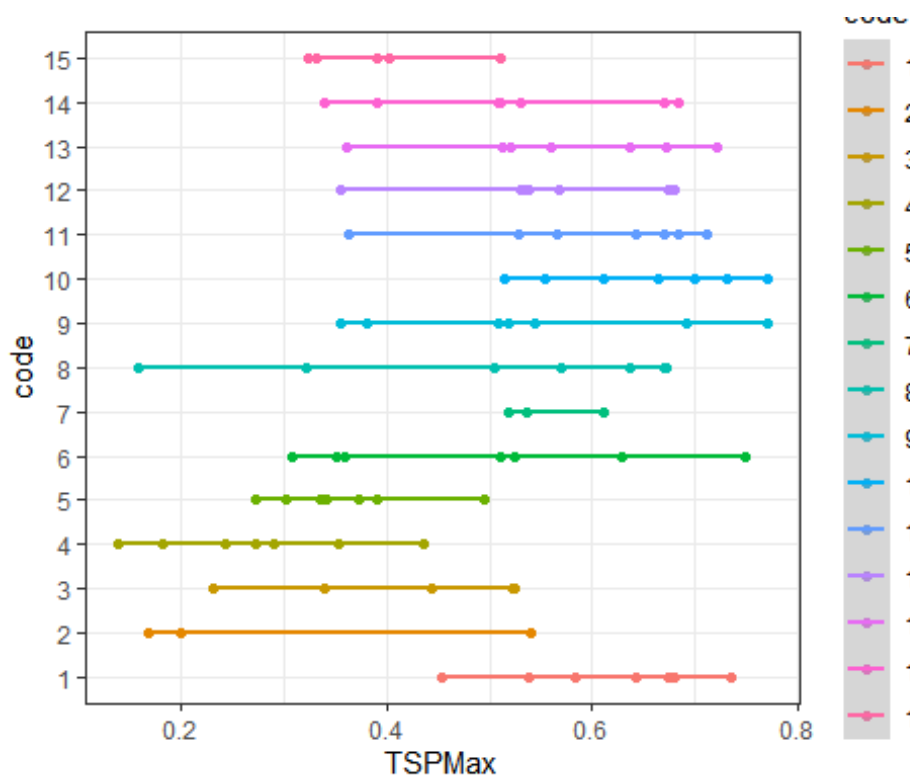


```
ggplot(PMdata, aes(x = TSPMax, y = code, color = code)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

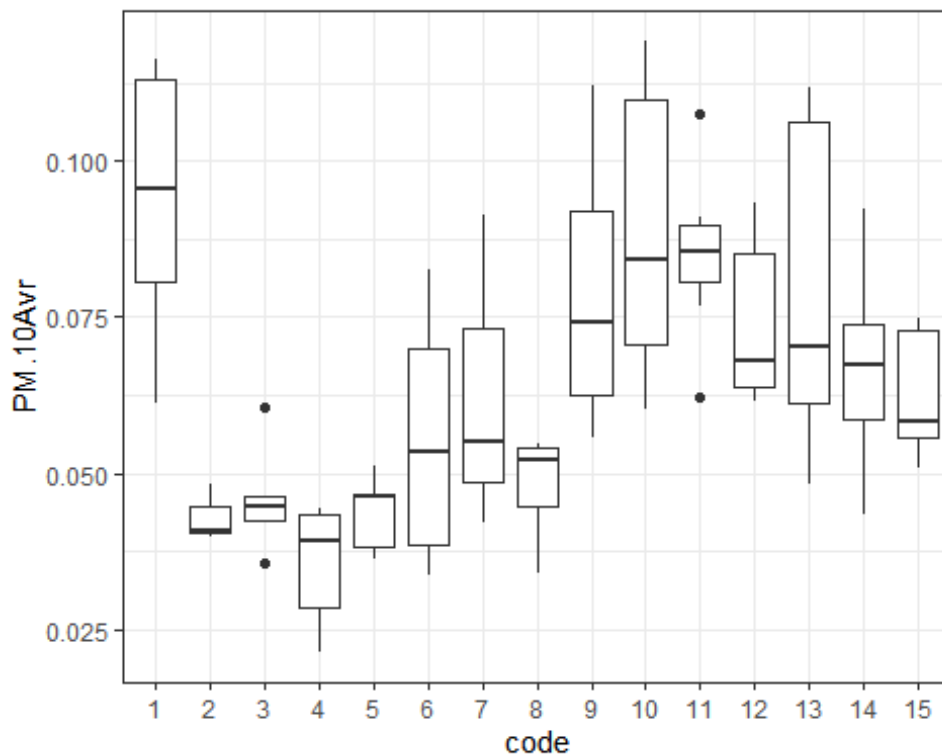
## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```



```
ggplot(PMdata, aes(x = code, y = PM.10Avr)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

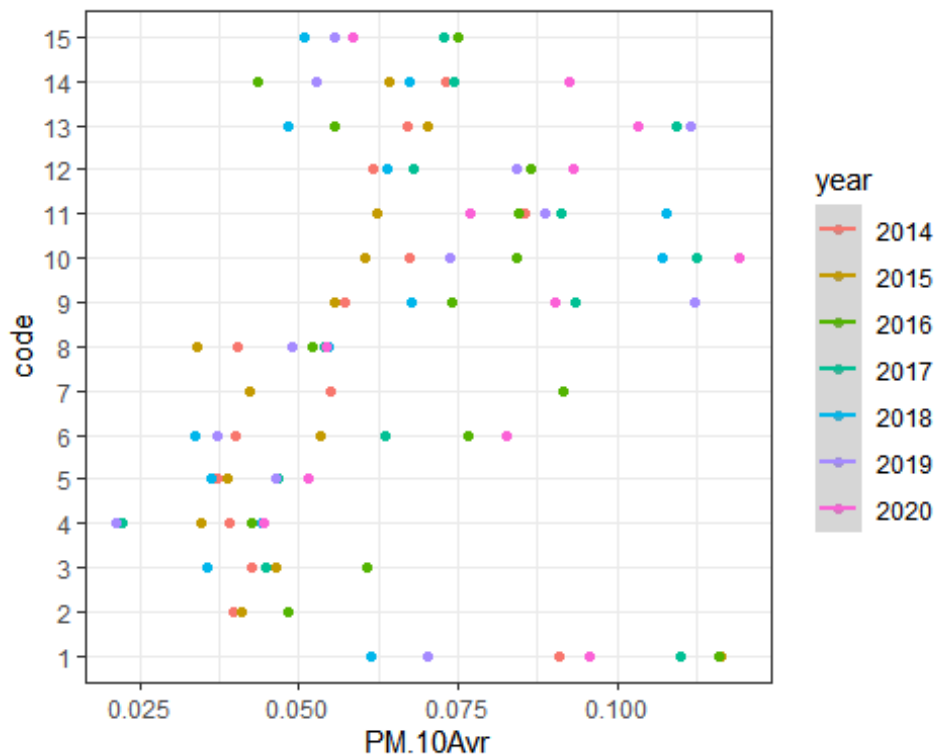



```
ggplot(PMdata, aes(x = PM.10Avr, y = code, color = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```

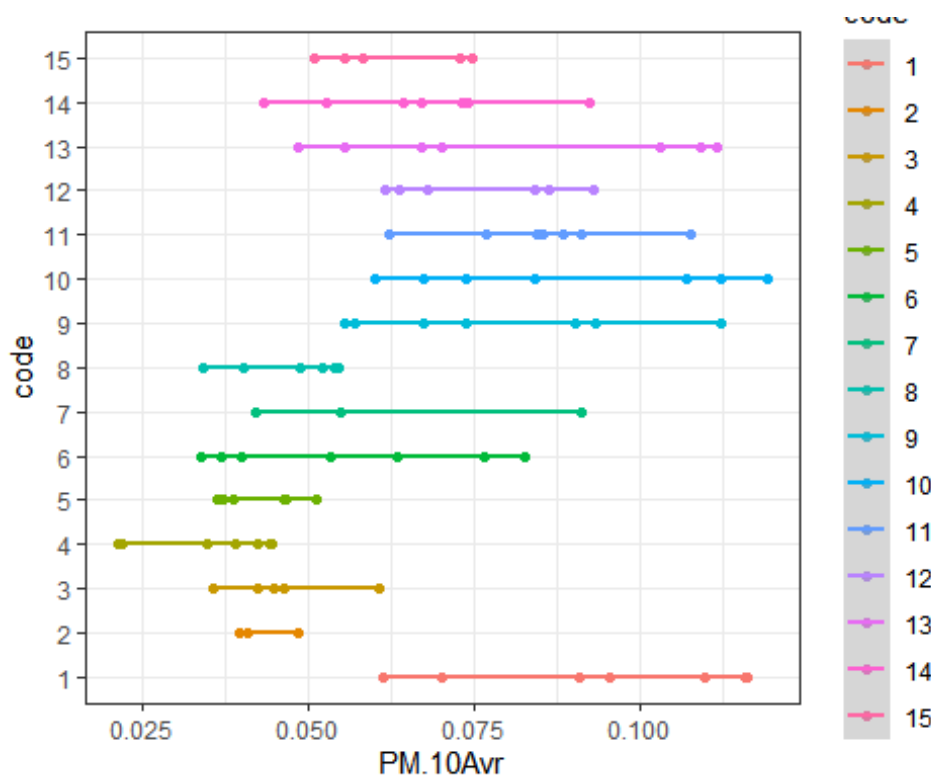


```
ggplot(PMdata, aes(x = PM.10Avr, y = code, color = code)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

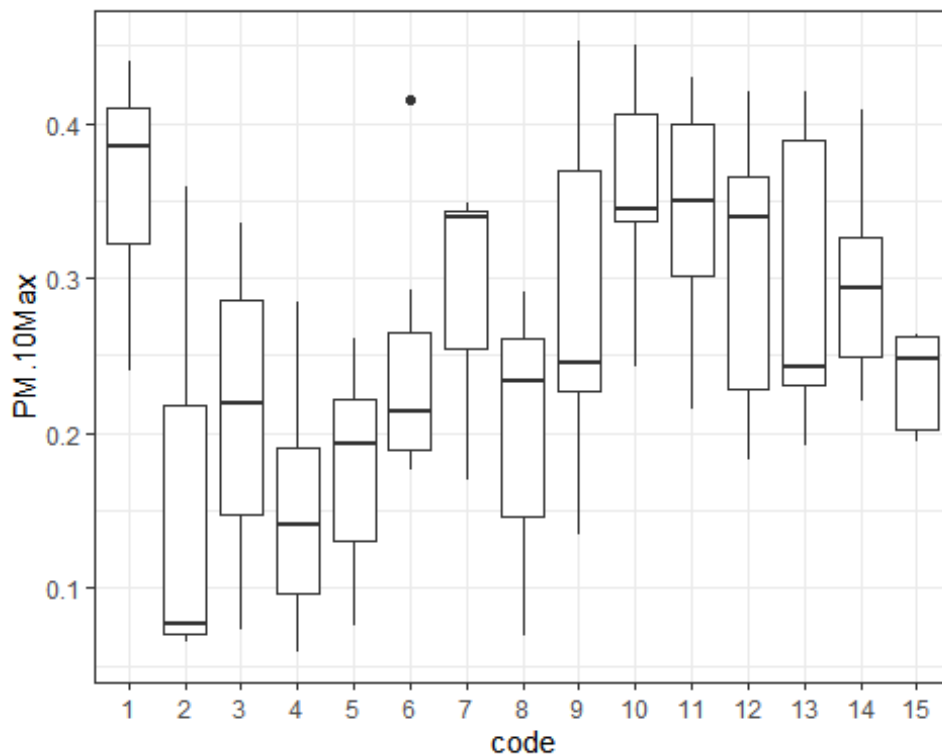
## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```



```
ggplot(PMdata, aes(x = code, y = PM.10Max)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

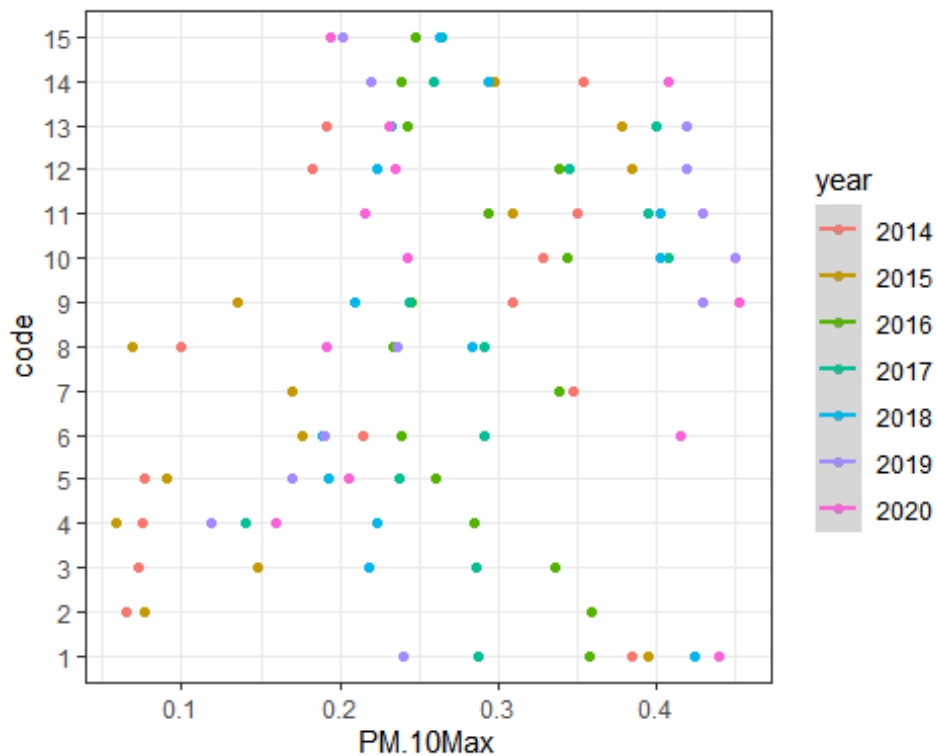


```
ggplot(PMdata, aes(x = PM.10Max, y = code, color = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```

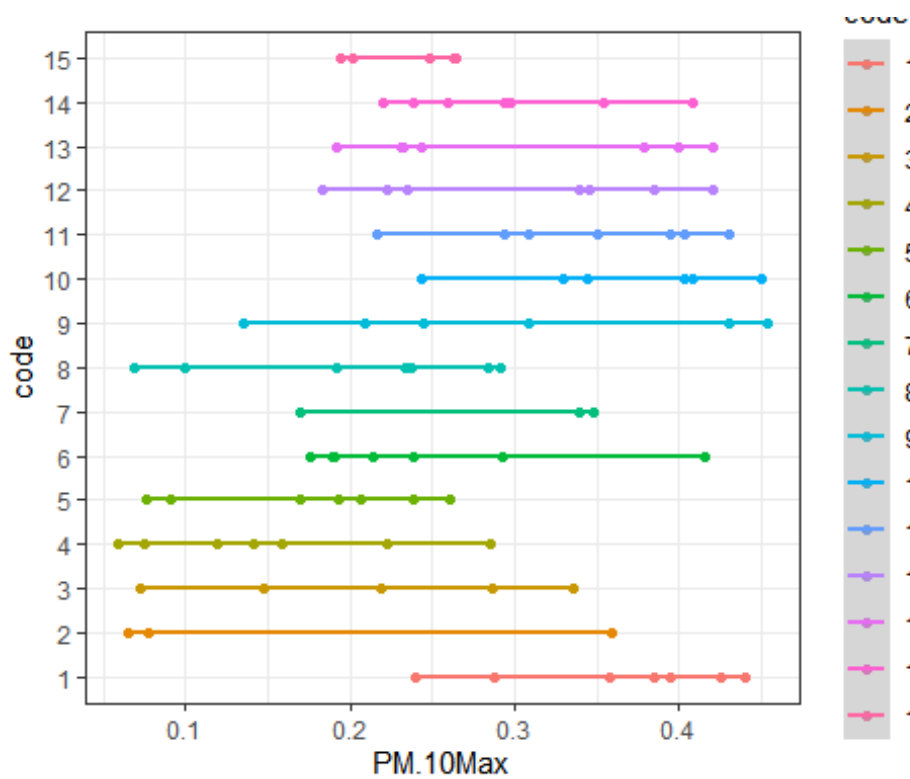


```
ggplot(PMdata, aes(x = PM.10Max, y = code, color = code)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

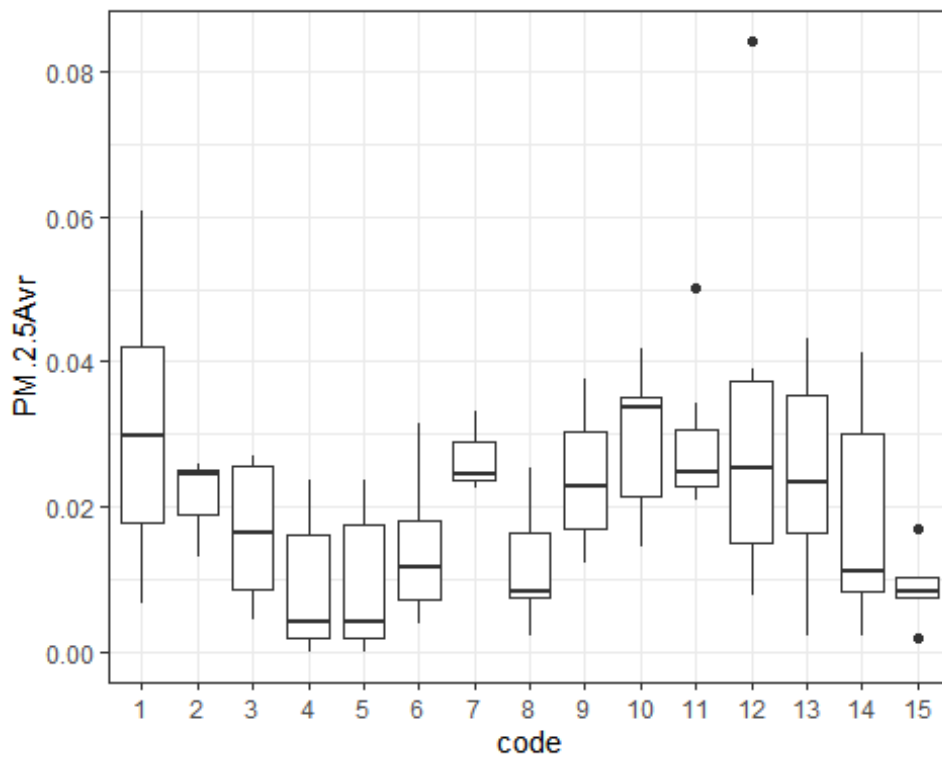
## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```



```
ggplot(PMdata, aes(x = code, y = PM.2.5Avr)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

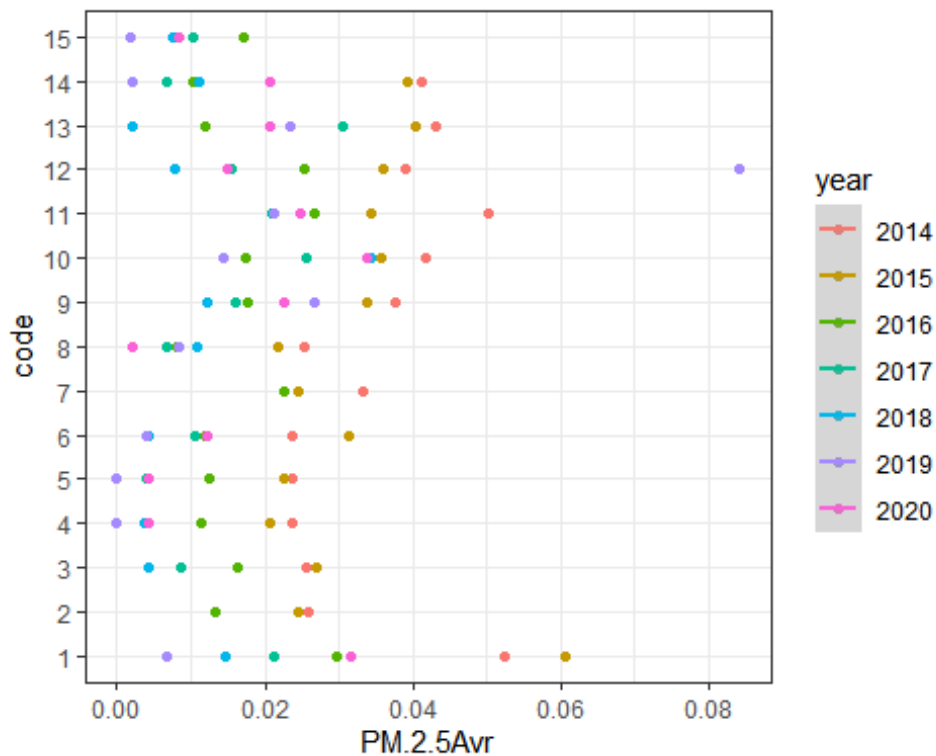


```
ggplot(PMdata, aes(x = PM.2.5Avr, y = code, color = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```

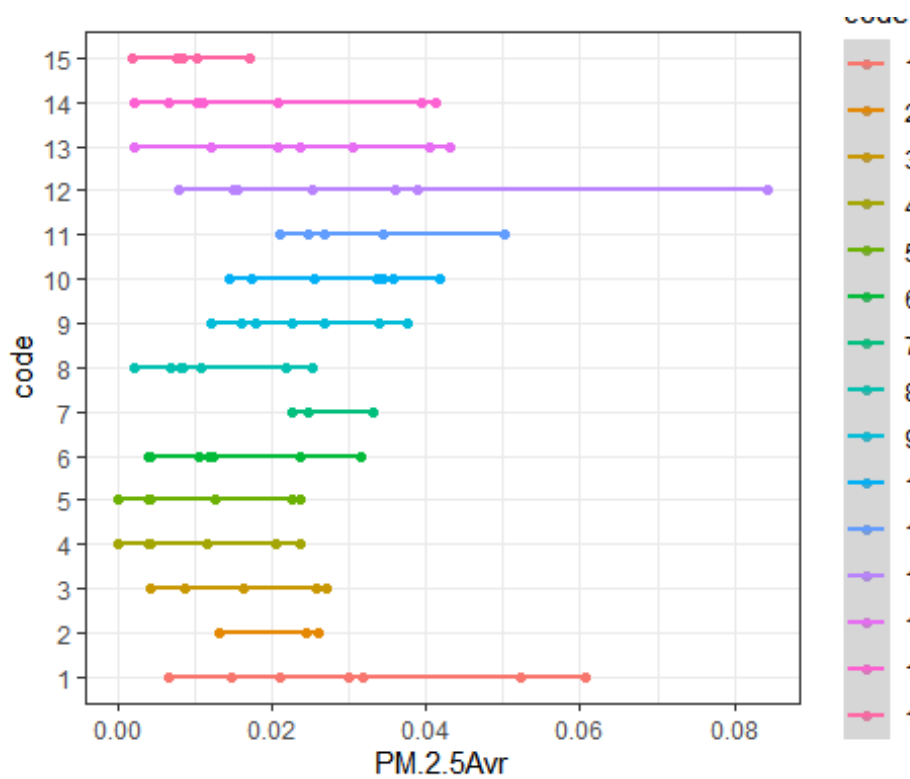


```
ggplot(PMdata, aes(x = PM.2.5Avr, y = code, color = code)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

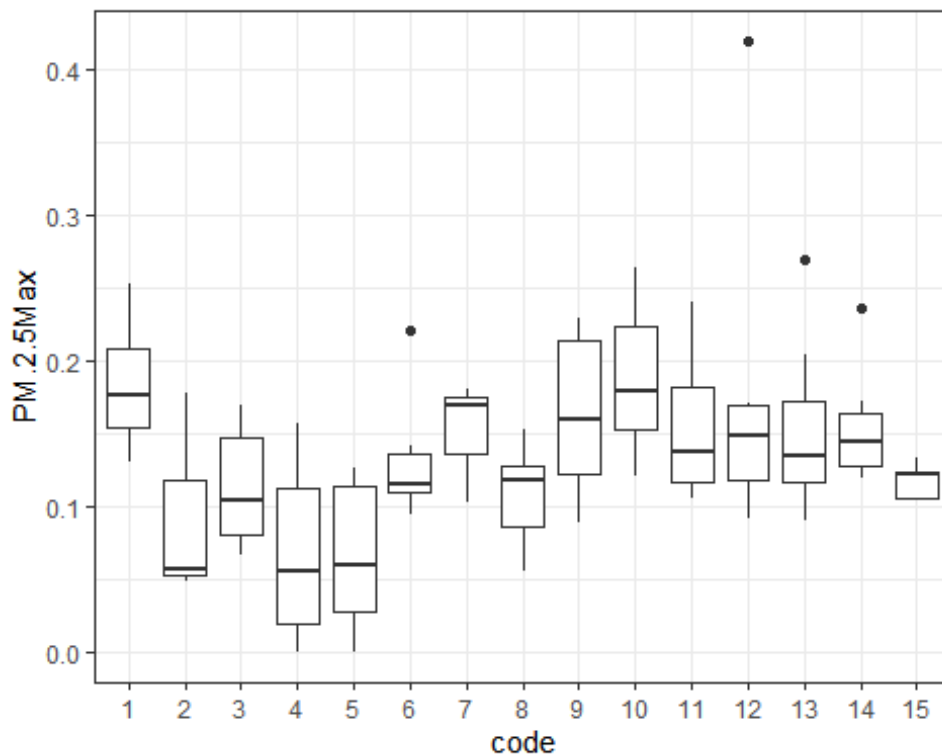
## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```



```
ggplot(PMdata, aes(x = code, y = PM.2.5Max)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

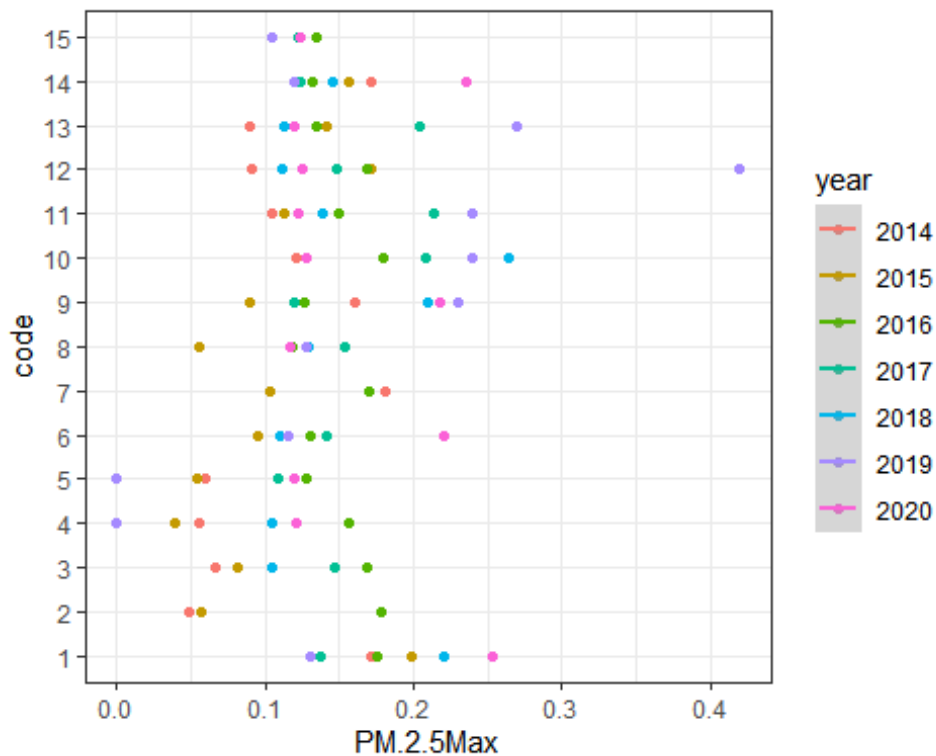


```
ggplot(PMdata, aes(x = PM.2.5Max, y = code, color = year)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```

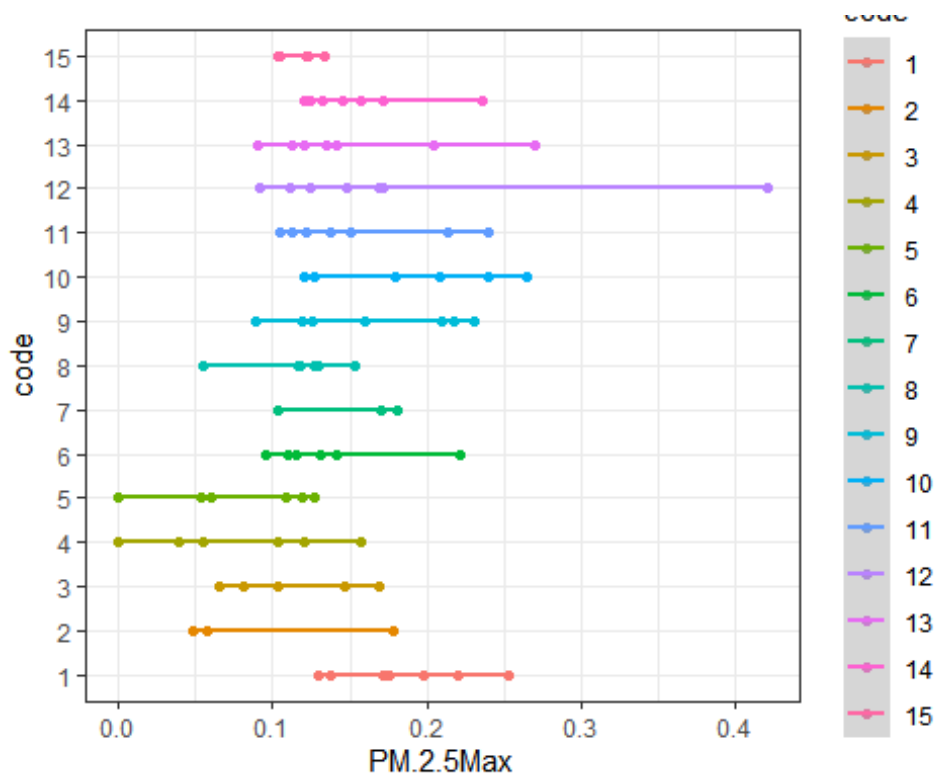


```
ggplot(PMdata, aes(x = PM.2.5Max, y = code, color = code)) +
  geom_point() +
  geom_smooth(se = TRUE, method = "lm", size = 1)

## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 12 rows containing non-finite values (stat_smooth).

## Warning: Removed 12 rows containing missing values (geom_point).
```



##Дисперсность в разных мониторинговых точках##

###среднегодовые концентрации PM2.5 тем выше, чем больше концентрации PM10###
 ###дисперсность не различалась в мониторинговых точках, кроме точки 12###

```
modPM25 <- lmer(PM.2.5Avr ~ PM.10Avr + code + (1+PM.10Avr|year), PMdata)
modPM25.1 <- lmer(PM.2.5Avr ~ PM.10Avr*code + (1+PM.10Avr|year), PMdata)
```

boundary (singular) fit: see ?isSingular

```
isSingular(modPM25.1)
```

```
## [1] TRUE
```

```
anova(modPM25)
```

Analysis of Variance Table

```
##          npar      Sum Sq   Mean Sq F value
## PM.10Avr     1  0.0044335  0.0044335  69.3438
## code        14  0.0007110  0.0000508   0.7943
```

```
summary(modPM25)
```

Linear mixed model fit by REML ['lmerMod']

Formula: PM.2.5Avr ~ PM.10Avr + code + (1 + PM.10Avr | year)

Data: PMdata

##

REML criterion at convergence: -481.9

##

Scaled residuals:

```
##      Min       1Q   Median       3Q      Max
```



```
## -1.8870 -0.3754 0.0140 0.2835 6.6268
##
## Random effects:
##   Groups   Name                Variance Std.Dev. Corr
##   year      (Intercept) 4.153e-05 0.006444
##             PM.10Avr    6.686e-03 0.081767 1.00
## Residual                    6.394e-05 0.007996
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) -4.063e-03 6.978e-03 -0.582
## PM.10Avr     3.676e-01 6.893e-02 5.332
## code2        1.640e-03 6.283e-03 0.261
## code3        1.569e-03 5.497e-03 0.285
## code4        6.062e-05 5.593e-03 0.011
## code5       -2.025e-03 5.308e-03 -0.381
## code6       -1.809e-03 4.921e-03 -0.368
## code7       -2.159e-04 5.840e-03 -0.037
## code8       -1.251e-03 5.133e-03 -0.244
## code9       -2.153e-05 4.393e-03 -0.005
## code10      1.584e-03 4.293e-03 0.369
## code11      2.248e-03 4.313e-03 0.521
## code12      8.969e-03 4.453e-03 2.014
## code13     -4.277e-04 4.365e-03 -0.098
## code14     -1.698e-03 4.599e-03 -0.369
## code15     -3.277e-03 5.197e-03 -0.631
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

anova(modPM25.1)

## Analysis of Variance Table
##              npar      Sum Sq   Mean Sq F value
## PM.10Avr         1 0.0041419 0.0041419 57.0818
## code            14 0.0007199 0.0000514  0.7087
## PM.10Avr:code    14 0.0003954 0.0000282  0.3892

summary(modPM25.1)

## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.2.5Avr ~ PM.10Avr * code + (1 + PM.10Avr | year)
##   Data: PMdata
##
## REML criterion at convergence: -481.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.8338 -0.2627 -0.0018  0.1990  5.5862
##
```

```

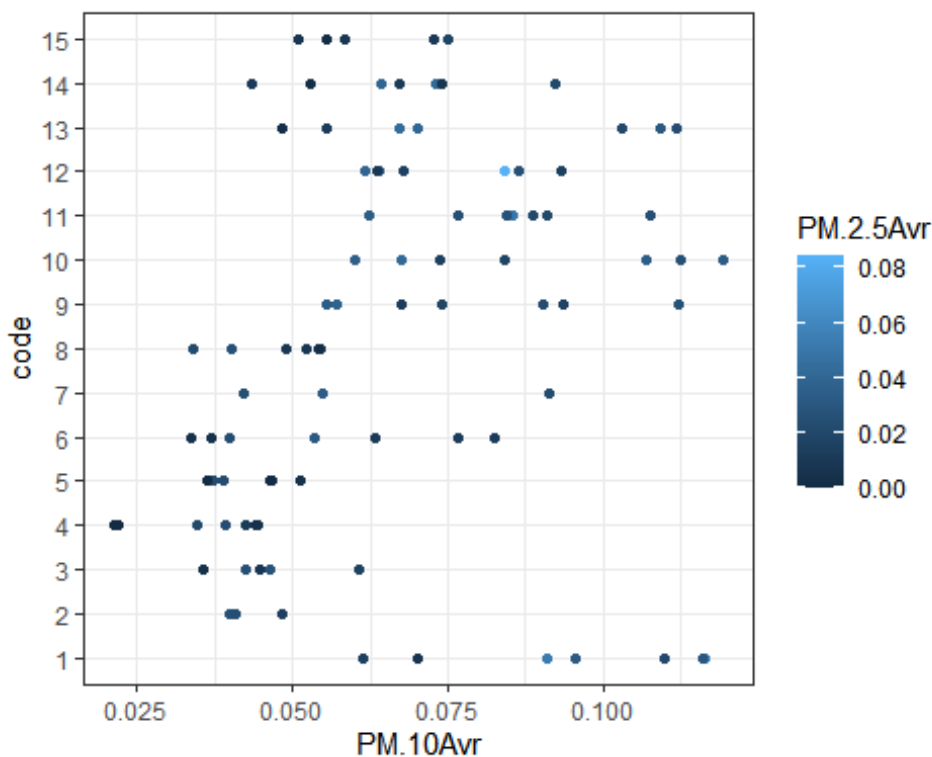
## Random effects:
##   Groups   Name                Variance Std.Dev. Corr
##   year     (Intercept) 3.260e-05 0.005710
##           PM.10Avr      8.957e-03 0.094642 1.00
## Residual                7.256e-05 0.008518
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##               Estimate Std. Error t value
## (Intercept)   -0.0077303  0.0163858  -0.472
## PM.10Avr       0.4063303  0.1731848   2.346
## code2         -0.0122902  0.0593895  -0.207
## code3         -0.0005619  0.0269766  -0.021
## code4          0.0042928  0.0208270   0.206
## code5          0.0063476  0.0315178   0.201
## code6          0.0072582  0.0189835   0.382
## code7          0.0048959  0.0229768   0.213
## code8          0.0107642  0.0276253   0.390
## code9          0.0136926  0.0221105   0.619
## code10        -0.0020321  0.0220105  -0.092
## code11         0.0146147  0.0293471   0.498
## code12        -0.0260656  0.0266831  -0.977
## code13         0.0044166  0.0201022   0.220
## code14         0.0011413  0.0226406   0.050
## code15        -0.0069973  0.0296536  -0.236
## PM.10Avr:code2  0.3801504  1.3353685   0.285
## PM.10Avr:code3  0.0881239  0.5005460   0.176
## PM.10Avr:code4 -0.0545623  0.3940316  -0.138
## PM.10Avr:code5 -0.1463768  0.6454928  -0.227
## PM.10Avr:code6 -0.1343792  0.2436422  -0.552
## PM.10Avr:code7 -0.0541775  0.2970092  -0.182
## PM.10Avr:code8 -0.2099329  0.4836243  -0.434
## PM.10Avr:code9 -0.1647705  0.2517692  -0.654
## PM.10Avr:code10 0.0451105  0.2353902   0.192
## PM.10Avr:code11 -0.1402881  0.3306720  -0.424
## PM.10Avr:code12 0.4825788  0.3287529   1.468
## PM.10Avr:code13 -0.0523275  0.2208586  -0.237
## PM.10Avr:code14 -0.0264089  0.2864602  -0.092
## PM.10Avr:code15 0.0798269  0.4344599   0.184
##
## Correlation matrix not shown by default, as p = 30 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
##
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
##
anova(modPM25.1,modPM25)
## refitting model(s) with ML (instead of REML)

```

```
## Data: PMdata
## Models:
## modPM25: PM.2.5Avr ~ PM.10Avr + code + (1 + PM.10Avr | year)
## modPM25.1: PM.2.5Avr ~ PM.10Avr * code + (1 + PM.10Avr | year)
##          npar      AIC      BIC logLik deviance Chisq Df Pr(>Chisq)
## modPM25      20 -587.83 -537.17 313.91 -627.83
## modPM25.1     34 -567.61 -481.51 317.81 -635.61 7.7875 14      0.9001

ggplot(PMdata, aes(x = PM.10Avr, y = code, color = PM.2.5Avr)) +
  geom_point()

## Warning: Removed 12 rows containing missing values (geom_point).
```



```
####среднегодовые максимальные концентрации PM2.5 тем выше,###
####чем больше концентрации PM10###
####дисперсность не различалась в мониторинговых точках###
modPM25m <- lmer(PM.2.5Max ~ PM.10Max + code + (1+PM.10Max|year), PMdata)

## boundary (singular) fit: see ?isSingular
isSingular(modPM25m)

## [1] TRUE

modPM25.1m <- lmer(PM.2.5Max ~ PM.10Max*code + (1+PM.10Max|year), PMdata)
anova(modPM25m)

## Analysis of Variance Table
##          npar    Sum Sq  Mean Sq  F value
## PM.10Max      1  0.210467  0.210467  176.4613
## code         14  0.013966  0.000998    0.8364
```

```
summary(modPM25m)

## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.2.5Max ~ PM.10Max + code + (1 + PM.10Max | year)
## Data: PMdata
##
## REML criterion at convergence: -267.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.1375 -0.3767 -0.0003  0.2877  4.7134
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## year (Intercept) 0.000000 0.00000
## PM.10Max 0.001886 0.04342 NaN
## Residual 0.001193 0.03454
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
## Estimate Std. Error t value
## (Intercept) 0.0109832 0.0213188 0.515
## PM.10Max 0.4800761 0.0491850 9.761
## code2 0.0047164 0.0256777 0.184
## code3 0.0029833 0.0214893 0.139
## code4 -0.0161933 0.0209767 -0.772
## code5 -0.0294583 0.0204747 -1.439
## code6 0.0027454 0.0193010 0.142
## code7 0.0091720 0.0243027 0.377
## code8 -0.0008354 0.0200307 -0.042
## code9 0.0120506 0.0188534 0.639
## code10 0.0039280 0.0185000 0.212
## code11 -0.0211991 0.0185265 -1.144
## code12 0.0182151 0.0187246 0.973
## code13 -0.0025047 0.0187605 -0.134
## code14 0.0025877 0.0187173 0.138
## code15 -0.0081309 0.0212641 -0.382
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it
##
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular

anova(modPM25.1m)

## Analysis of Variance Table
## npar Sum Sq Mean Sq F value
## PM.10Max 1 0.042491 0.042491 44.0351
## code 14 0.013327 0.000952 0.9865
## PM.10Max:code 14 0.014653 0.001047 1.0847
```

```
summary(modPM25.1m)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.2.5Max ~ PM.10Max * code + (1 + PM.10Max | year)
## Data: PMdata
##
## REML criterion at convergence: -272.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.24102 -0.42080  0.05231  0.32518  2.96732
##
## Random effects:
## Groups Name Variance Std.Dev. Corr
## year (Intercept) 0.0020221 0.04497
## PM.10Max 0.0366256 0.19138 -1.00
## Residual 0.0009649 0.03106
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
## Estimate Std. Error t value
## (Intercept) -0.026365 0.068489 -0.385
## PM.10Max 0.600355 0.195788 3.066
## code2 0.009192 0.073391 0.125
## code3 0.017094 0.076085 0.225
## code4 -0.008496 0.072273 -0.118
## code5 -0.003980 0.075624 -0.053
## code6 0.043827 0.075459 0.581
## code7 0.023031 0.094129 0.245
## code8 0.014313 0.074305 0.193
## code9 0.100030 0.073719 1.357
## code10 0.065694 0.098707 0.666
## code11 0.087243 0.090221 0.967
## code12 -0.066157 0.080910 -0.818
## code13 0.030471 0.079754 0.382
## code14 0.008073 0.087189 0.093
## code15 0.152343 0.127358 1.196
## PM.10Max:code2 -0.037736 0.233768 -0.161
## PM.10Max:code3 -0.062435 0.241864 -0.258
## PM.10Max:code4 0.064542 0.246658 0.262
## PM.10Max:code5 -0.075323 0.263451 -0.286
## PM.10Max:code6 -0.136649 0.233065 -0.586
## PM.10Max:code7 -0.037082 0.290426 -0.128
## PM.10Max:code8 -0.047234 0.237574 -0.199
## PM.10Max:code9 -0.318632 0.210512 -1.514
## PM.10Max:code10 -0.202780 0.273096 -0.743
## PM.10Max:code11 -0.342704 0.254558 -1.346
## PM.10Max:code12 0.262645 0.235852 1.114
## PM.10Max:code13 -0.127716 0.233312 -0.547
## PM.10Max:code14 0.001624 0.262327 0.006
## PM.10Max:code15 -0.629747 0.496186 -1.269
```

```
##
## Correlation matrix not shown by default, as p = 30 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

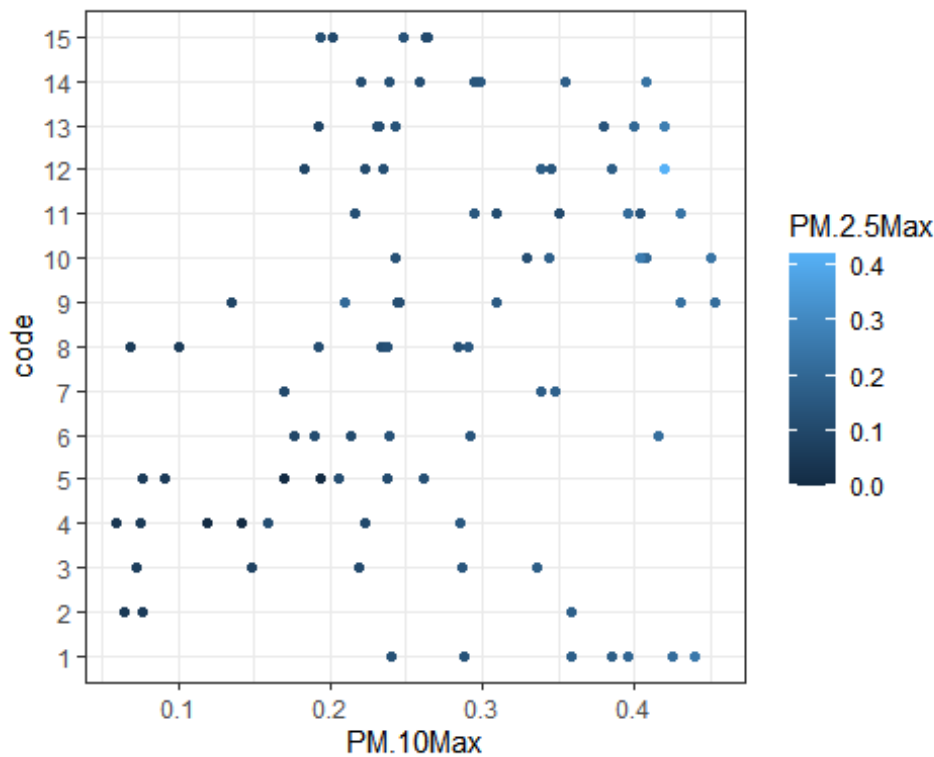
anova(modPM25.1m, modPM25m)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modPM25m: PM.2.5Max ~ PM.10Max + code + (1 + PM.10Max | year)
## modPM25.1m: PM.2.5Max ~ PM.10Max * code + (1 + PM.10Max | year)
##           npar      AIC      BIC logLik deviance Chisq Df Pr(>Chisq)
## modPM25m      20 -332.69 -282.04 186.35  -372.69
## modPM25.1m     34 -336.01 -249.90 202.00  -404.01 31.315 14  0.005007 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

ggplot(PMdata, aes(x = PM.10Max, y = code, color = PM.2.5Max)) +
  geom_point()

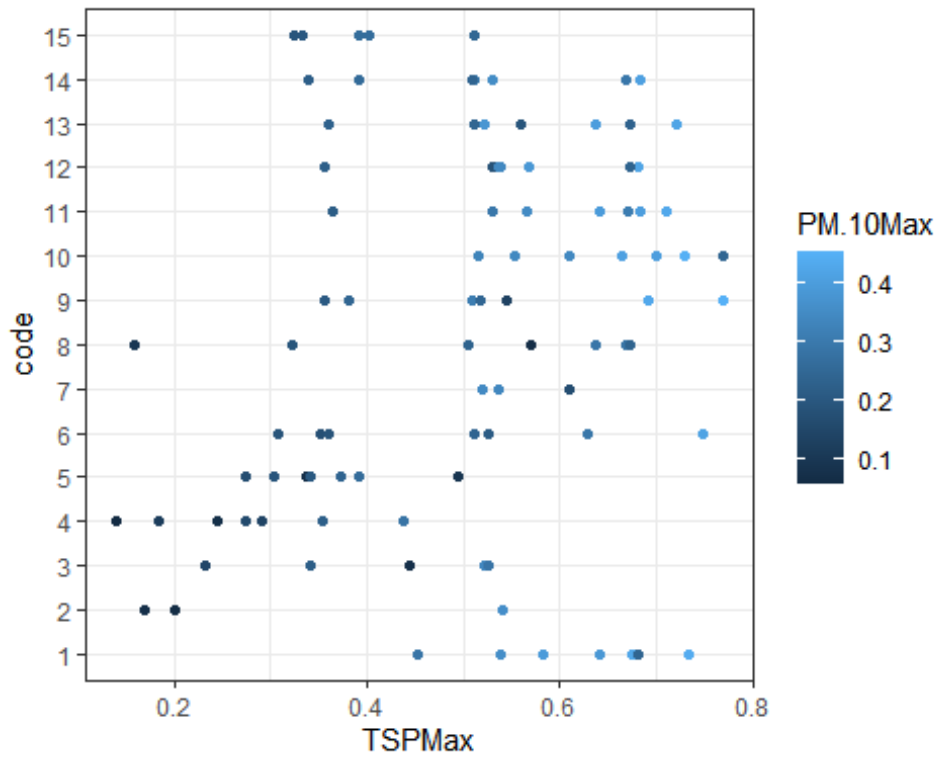
## Warning: Removed 12 rows containing missing values (geom_point).
```



###Визуализация дисперсности в разных точках###

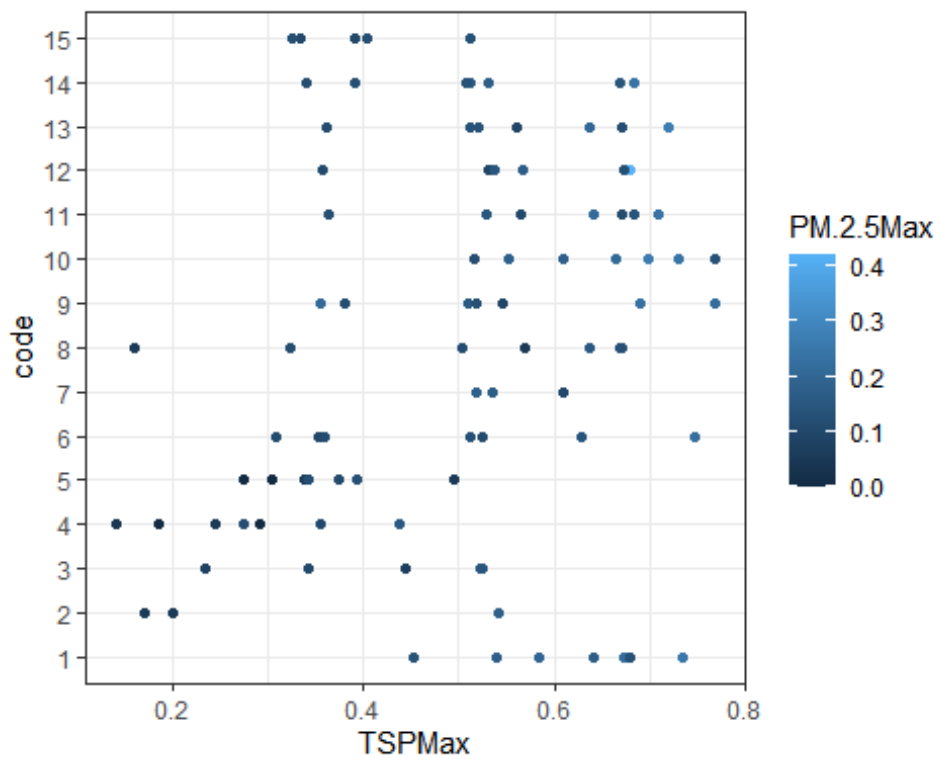
```
ggplot(PMdata, aes(x = TSPMax, y = code, color = PM.10Max)) +
  geom_point()

## Warning: Removed 12 rows containing missing values (geom_point).
```



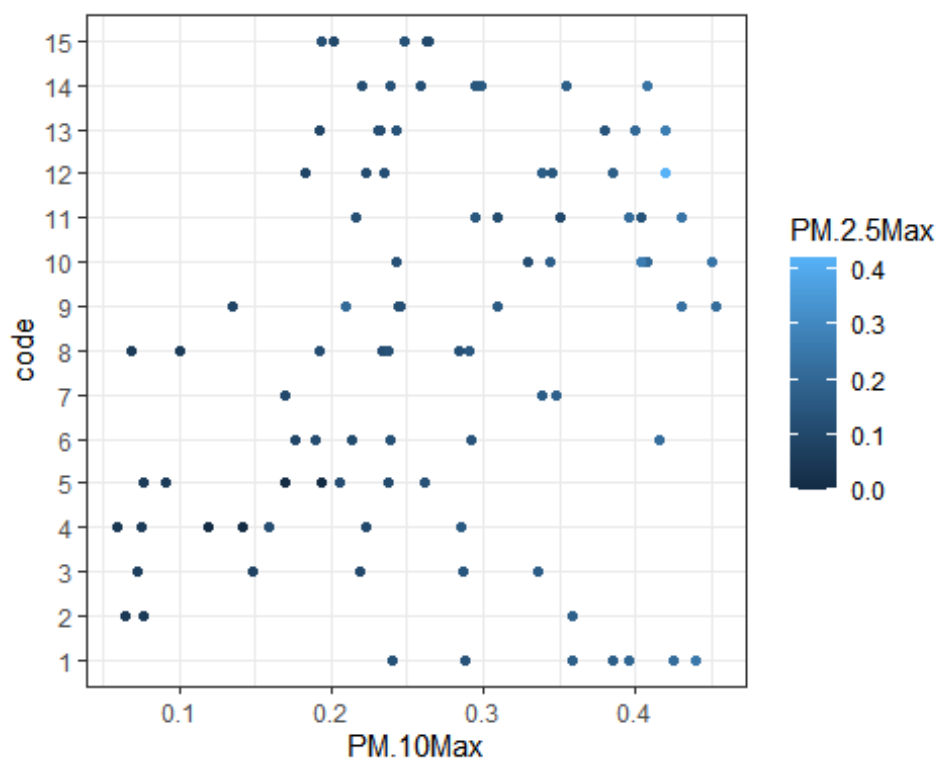
```
ggplot(PMdata, aes(x = TSPMax, y = code, color = PM.2.5Max)) +  
  geom_point()
```

Warning: Removed 12 rows containing missing values (geom_point).



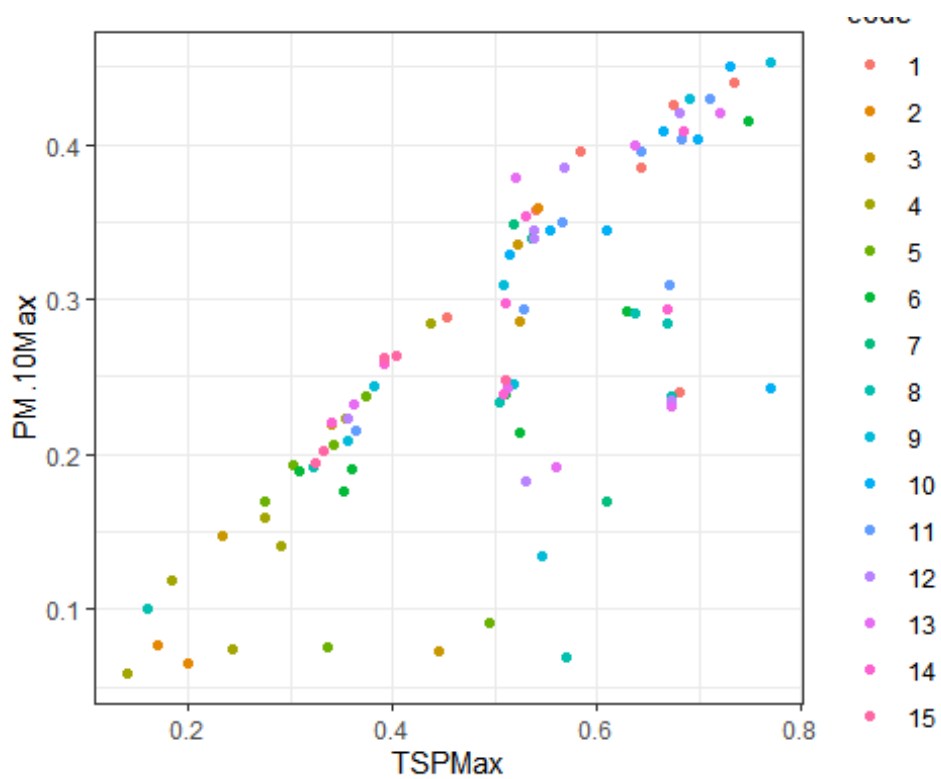
```
ggplot(PMdata, aes(x = PM.10Max, y = code, color = PM.2.5Max)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



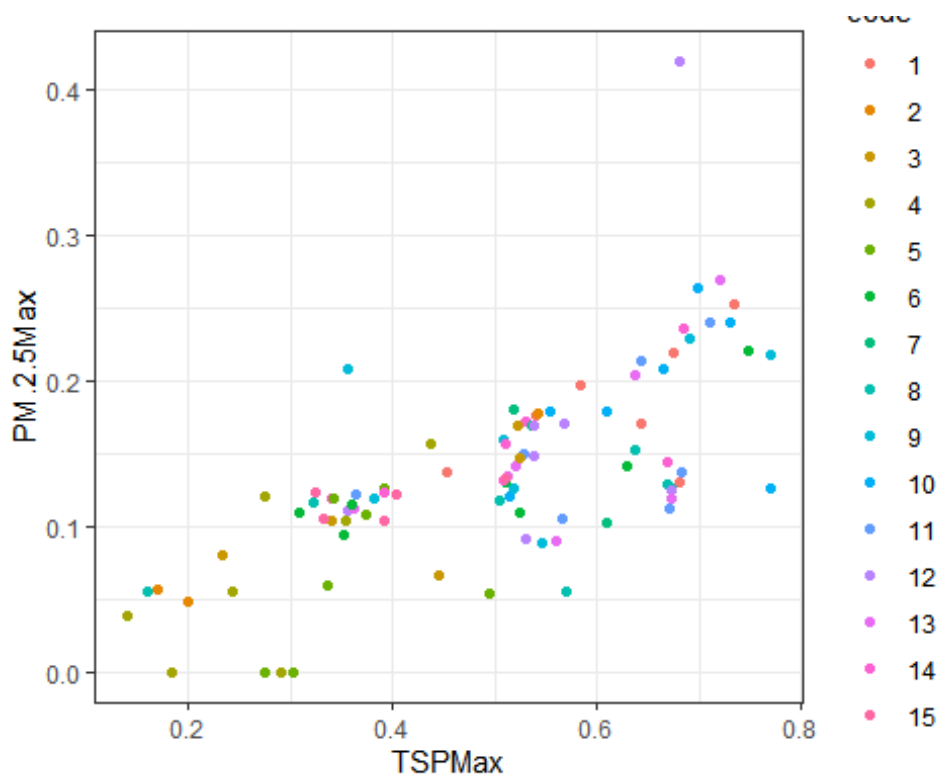
```
ggplot(PMdata, aes(x = TSPMax, y = PM.10Max, color = code)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```

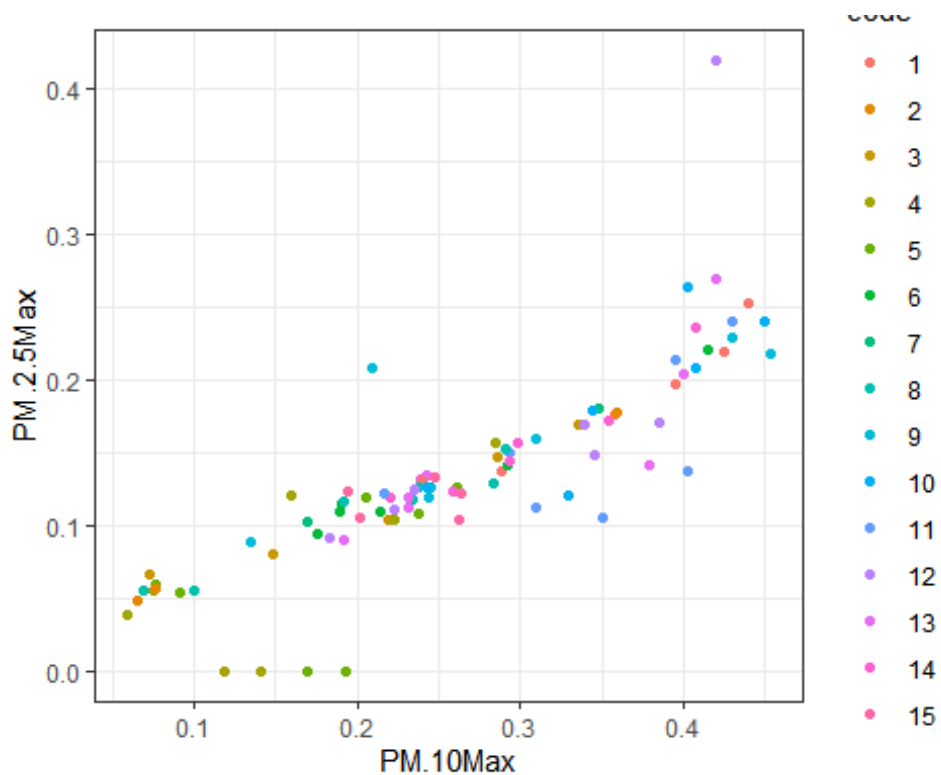
```
ggplot(PMdata, aes(x = TSPMax, y = PM.2.5Max, color = code)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



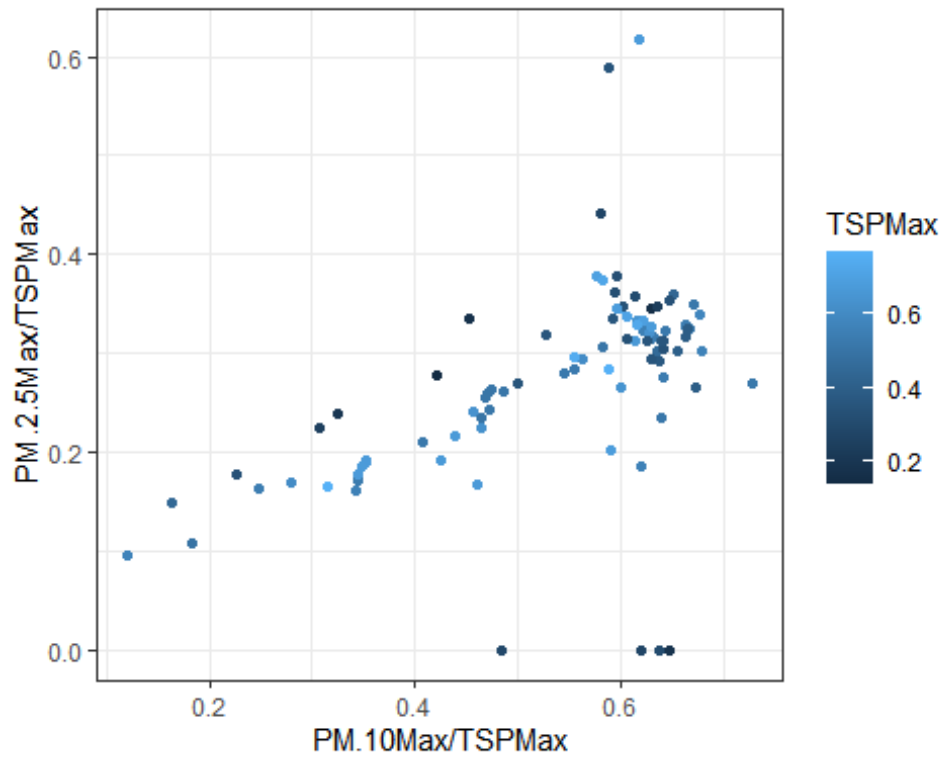
```
ggplot(PMdata, aes(x = PM.10Max, y = PM.2.5Max, color = code)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



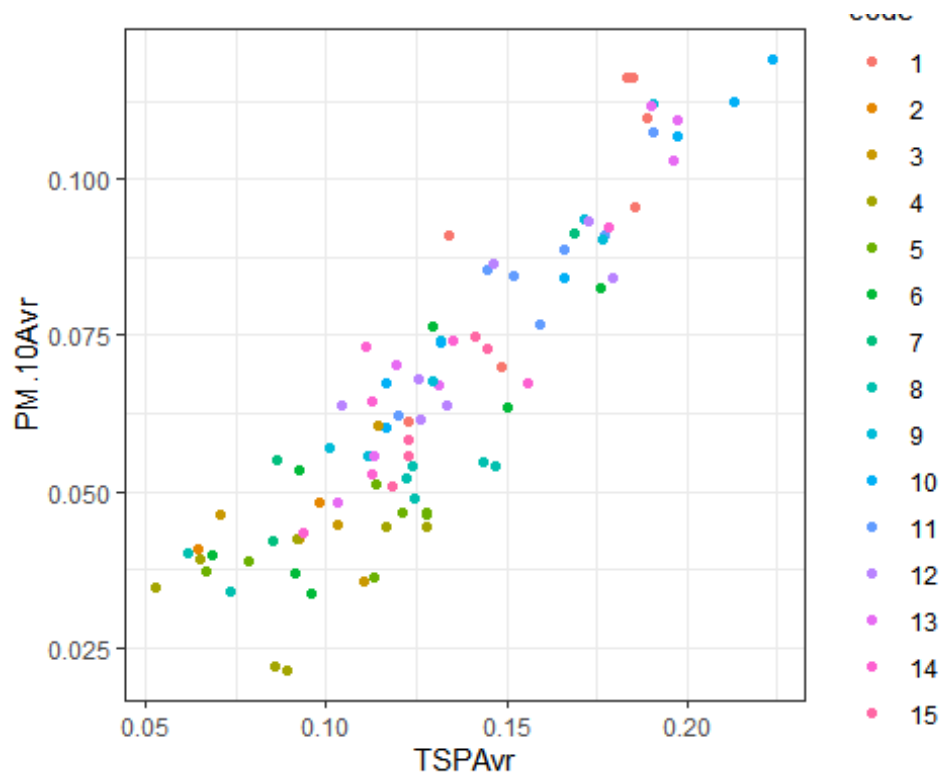
```
ggplot(PMdata, aes(x = PM.10Max/TSPMax, y = PM.2.5Max/TSPMax, color = TSPMax)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



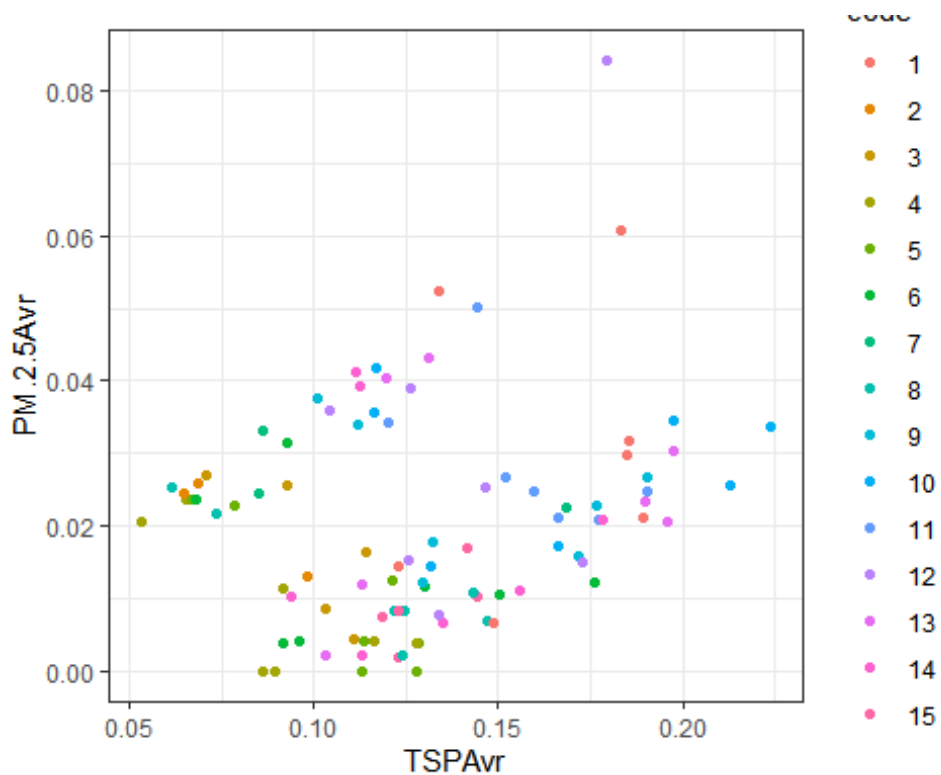
```
ggplot(PMdata, aes(x = TSPAavr, y = PM.10Avr, color = code)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



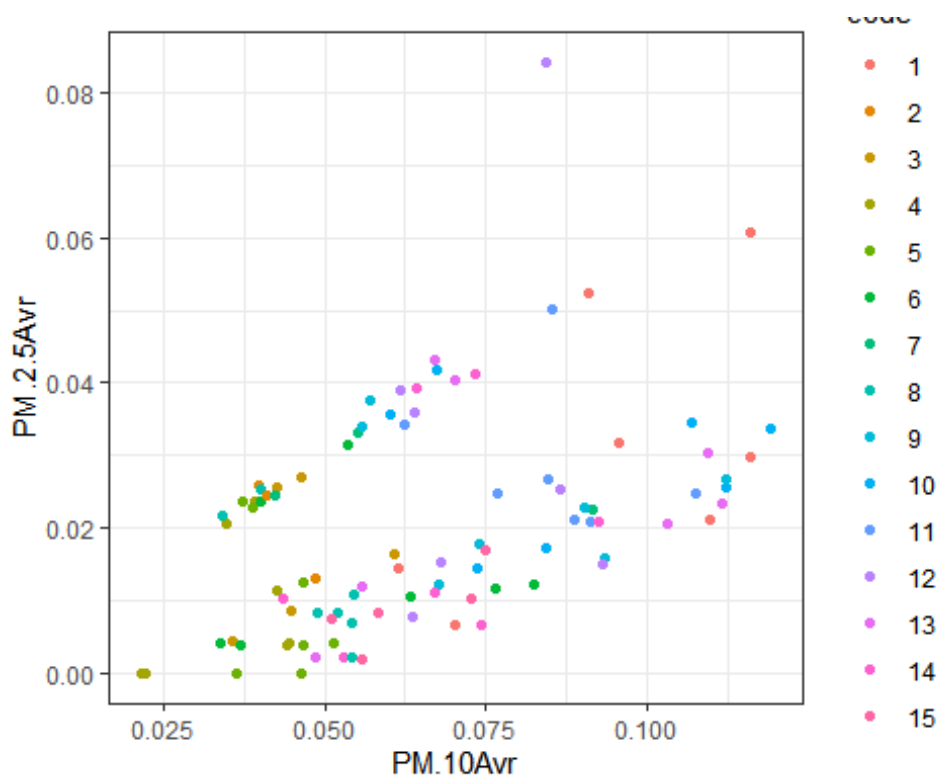
```
ggplot(PMdata, aes(x = TSPAwr, y = PM.2.5Avr, color = code)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



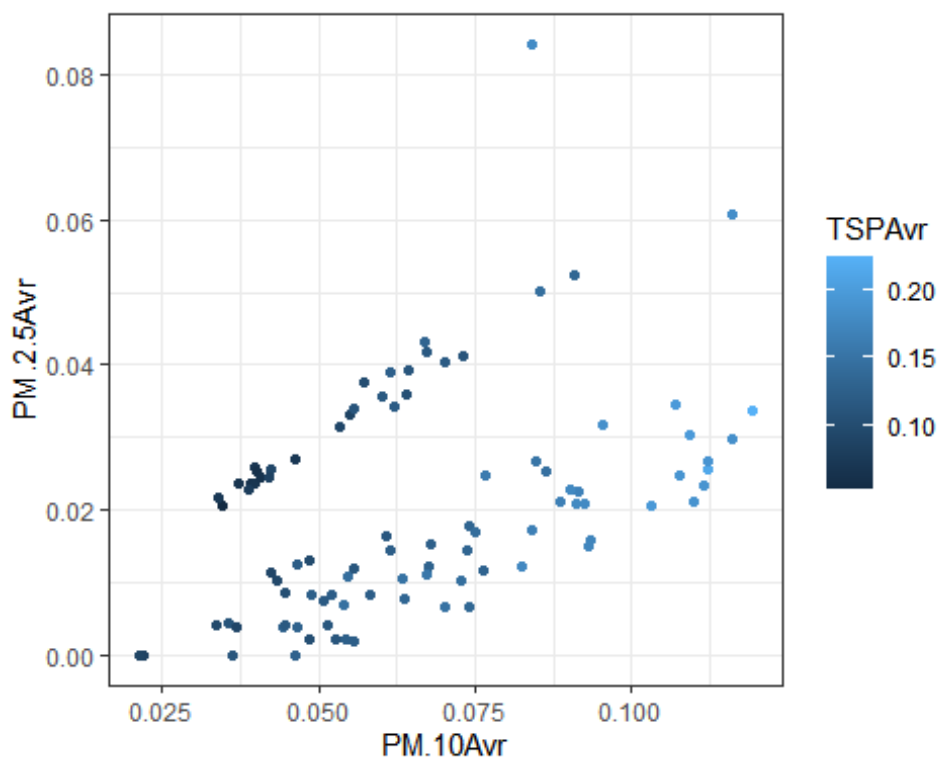
```
ggplot(PMdata, aes(x = PM.10Avr, y = PM.2.5Avr, color = code)) +  
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



```
ggplot(PMdata, aes(x = PM.10Avr, y = PM.2.5Avr, color = TSPAvr)) +
  geom_point()
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
```



```

##Динамика РМ во времени##
###Рост среднегодовых концентраций для общей фракции аэрозоля и РМ10, снижение -
для РМ2.5###
###Стабильные среднегодовые максимальные концентрации для общей фракции, рост -
для РМ10 и РМ2.5###

##РМ2.5Avr - Уменьшается во времени###
mod25time <- lm(PM.2.5Avr ~ code + year, PMdata)
anova(mod25time)

## Analysis of Variance Table
##
## Response: PM.2.5Avr
##           Df      Sum Sq    Mean Sq F value    Pr(>F)
## code       14  0.0062883  0.00044916   4.7282 4.886e-06 ***
## year        6  0.0069611  0.00116019  12.2129 1.997e-09 ***
## Residuals  72  0.0068398  0.00009500
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(mod25time)

##
## Call:
## lm(formula = PM.2.5Avr ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.019865 -0.003841 -0.000306  0.003364  0.056935
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.045787   0.004432  10.331 7.32e-16 ***
## code2       -0.017975   0.006836  -2.630 0.010446 *
## code3       -0.016246   0.005747  -2.827 0.006083 **
## code4       -0.021857   0.005210  -4.195 7.66e-05 ***
## code5       -0.021386   0.005210  -4.105 0.000105 ***
## code6       -0.016986   0.005210  -3.260 0.001701 **
## code7       -0.012375   0.006836  -1.810 0.074412 .
## code8       -0.019057   0.005210  -3.658 0.000481 ***
## code9       -0.007157   0.005210  -1.374 0.173771
## code10      -0.002000   0.005210  -0.384 0.702190
## code11      -0.002000   0.005210  -0.384 0.702190
## code12       0.000800   0.005210   0.154 0.878389
## code13      -0.006371   0.005210  -1.223 0.225329
## code14      -0.012200   0.005210  -2.342 0.021964 *
## code15      -0.016461   0.005744  -2.866 0.005453 **
## year2015     -0.002379   0.003684  -0.646 0.520546
## year2016     -0.017555   0.003635  -4.830 7.47e-06 ***
## year2017     -0.021400   0.003818  -5.605 3.61e-07 ***
## year2018     -0.024369   0.003818  -6.382 1.49e-08 ***
## year2019     -0.019322   0.003916  -4.934 5.03e-06 ***
## year2020     -0.018680   0.003916  -4.770 9.36e-06 ***

```

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.009747 on 72 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.6595, Adjusted R-squared:  0.565
## F-statistic: 6.974 on 20 and 72 DF,  p-value: 3.409e-10

####точка как случайный эффект###
mod25timeMM <- lmer(PM.2.5Avr ~ year + (1|code), PMdata)
anova(mod25timeMM)

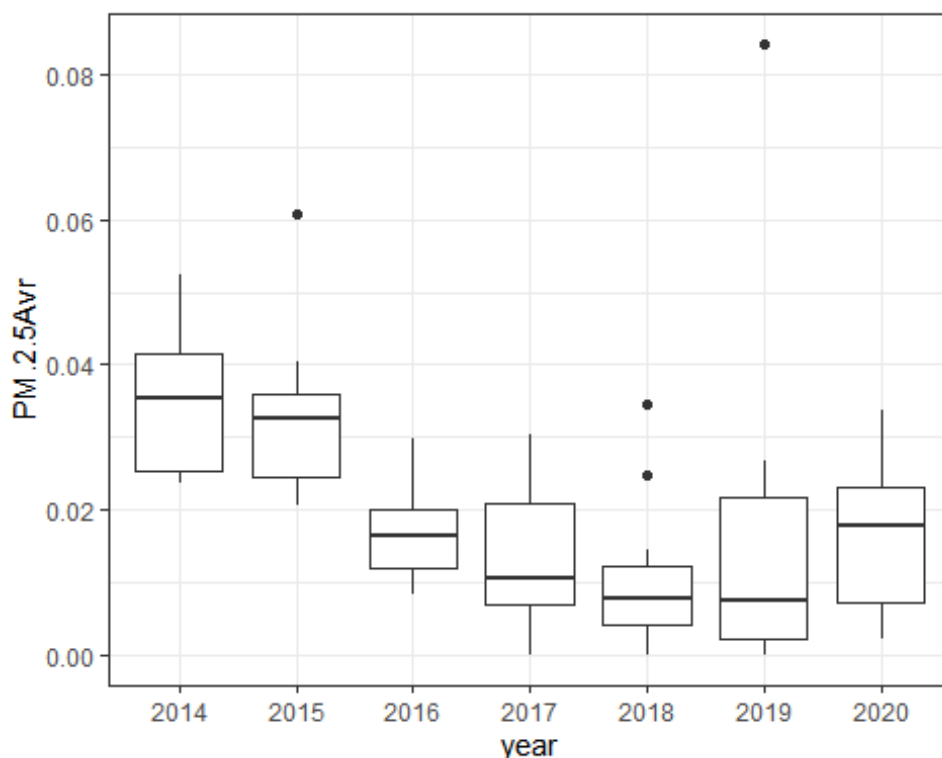
## Analysis of Variance Table
##      npar      Sum Sq   Mean Sq F value
## year      6 0.0070577 0.0011763  12.452

summary(mod25timeMM)

## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.2.5Avr ~ year + (1 | code)
##      Data: PMdata
##
## REML criterion at convergence: -514.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8177 -0.4630 -0.1062  0.3551  6.1013
##
## Random effects:
##      Groups   Name      Variance Std.Dev.
##      code     (Intercept) 5.101e-05 0.007142
##      Residual                9.447e-05 0.009719
## Number of obs: 93, groups:  code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.034454   0.003196  10.780
## year2015     -0.002379   0.003674  -0.647
## year2016     -0.017641   0.003621  -4.872
## year2017     -0.021271   0.003784  -5.621
## year2018     -0.024240   0.003784  -6.406
## year2019     -0.019073   0.003877  -4.920
## year2020     -0.018432   0.003877  -4.754
##
## Correlation of Fixed Effects:
##              (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015    -0.575
## year2016    -0.589  0.507
## year2017    -0.565  0.485  0.499
## year2018    -0.565  0.485  0.499  0.493
## year2019    -0.552  0.474  0.487  0.481  0.481
## year2020    -0.552  0.474  0.487  0.481  0.481  0.476

```

```
ggplot(PMdata, aes(x = year, y = PM.2.5Avr)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



```
mod25timenullMM <- lmer(PM.2.5Avr ~ (1|code), PMdata)
anova(mod25timenullMM, mod25timeMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## mod25timenullMM: PM.2.5Avr ~ (1 | code)
## mod25timeMM: PM.2.5Avr ~ year + (1 | code)
##               npar      AIC      BIC logLik deviance  Chisq Df Pr(>Chisq)
## mod25timenullMM    3 -521.35 -513.75 263.67  -527.35
## mod25timeMM        9 -565.46 -542.67 291.73  -583.46 56.111  6 2.765e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#PM10Avr - Увеличивается во времени
mod10time <- lm(PM.10Avr ~ code + year, PMdata)
anova(mod10time)

## Analysis of Variance Table
##
## Response: PM.10Avr
##              Df    Sum Sq   Mean Sq F value    Pr(>F)
## code         14  0.031857  0.00227550   9.7161 1.156e-11 ***
## year          6  0.005514  0.00091894   3.9238 0.001899 **
## Residuals    72  0.016862  0.00023420
```



```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(mod10time)

##
## Call:
## lm(formula = PM.10Avr ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.029393 -0.008836 -0.000800  0.007735  0.034269
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.0858547  0.0069587  12.338 < 2e-16 ***
## code2        -0.0467222  0.0107331  -4.353 4.36e-05 ***
## code3        -0.0459209  0.0090237  -5.089 2.77e-06 ***
## code4        -0.0587857  0.0081801  -7.186 5.00e-10 ***
## code5        -0.0510000  0.0081801  -6.235 2.75e-08 ***
## code6        -0.0390571  0.0081801  -4.775 9.20e-06 ***
## code7        -0.0269222  0.0107331  -2.508 0.014384 *
## code8        -0.0459857  0.0081801  -5.622 3.37e-07 ***
## code9        -0.0157000  0.0081801  -1.919 0.058911 .
## code10       -0.0051429  0.0081801  -0.629 0.531533
## code11       -0.0091143  0.0081801  -1.114 0.268898
## code12       -0.0198714  0.0081801  -2.429 0.017627 *
## code13       -0.0135429  0.0081801  -1.656 0.102158
## code14       -0.0275000  0.0081801  -3.362 0.001242 **
## code15       -0.0353738  0.0090196  -3.922 0.000198 ***
## year2015     -0.0009786  0.0057842  -0.169 0.866129
## year2016      0.0126813  0.0057070   2.222 0.029423 *
## year2017      0.0163834  0.0059952   2.733 0.007897 **
## year2018      0.0022449  0.0059952   0.374 0.709168
## year2019      0.0077765  0.0061491   1.265 0.210076
## year2020      0.0210098  0.0061491   3.417 0.001046 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0153 on 72 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.6891, Adjusted R-squared:  0.6027
## F-statistic: 7.978 on 20 and 72 DF, p-value: 1.893e-11

#точка как случайный эффект
mod10timeMM <- lmer(PM.10Avr ~ year + (1|code), PMdata)
anova(mod10timeMM)

## Analysis of Variance Table
##      npar    Sum Sq   Mean Sq F value
## year     6 0.0056599 0.00094331  4.0375

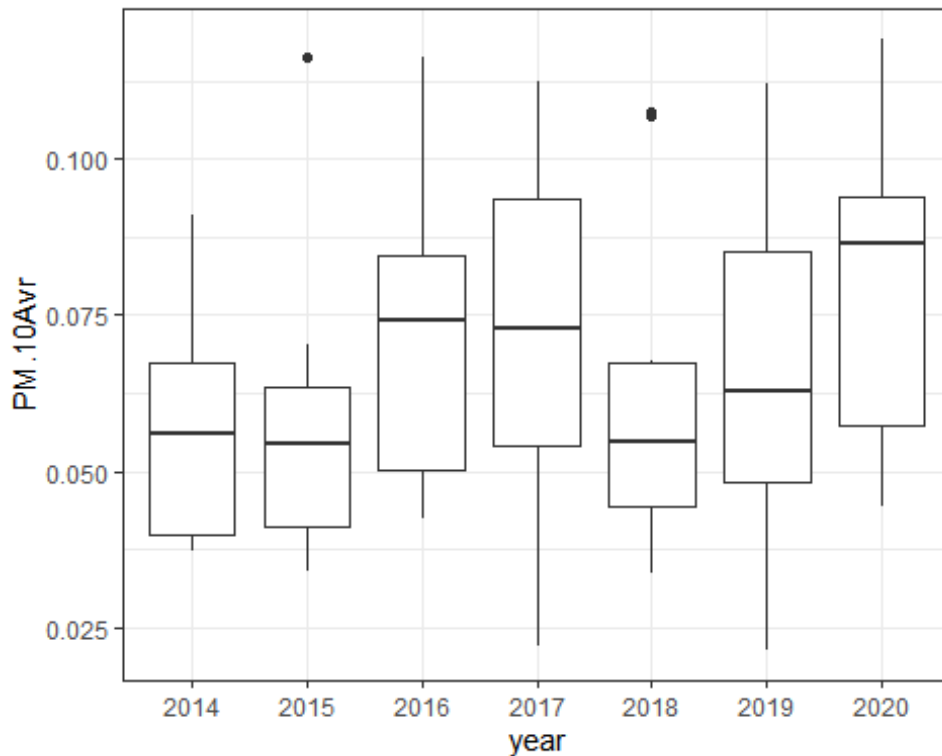
summary(mod10timeMM)
```

```

## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.10Avr ~ year + (1 | code)
## Data: PMdata
##
## REML criterion at convergence: -426.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.80864 -0.56068 -0.05327  0.54075  2.31446
##
## Random effects:
## Groups Name Variance Std.Dev.
## code (Intercept) 0.0003036 0.01742
## Residual 0.0002336 0.01529
## Number of obs: 93, groups: code, 15
##
## Fixed effects:
## Estimate Std. Error t value
## (Intercept) 0.0565196 0.0060931 9.276
## year2015 -0.0009786 0.0057773 -0.169
## year2016 0.0126404 0.0056974 2.219
## year2017 0.0165730 0.0059683 2.777
## year2018 0.0024346 0.0059683 0.408
## year2019 0.0081614 0.0061183 1.334
## year2020 0.0213947 0.0061183 3.497
##
## Correlation of Fixed Effects:
## (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015 -0.474
## year2016 -0.486 0.507
## year2017 -0.466 0.484 0.498
## year2018 -0.466 0.484 0.498 0.495
## year2019 -0.455 0.472 0.487 0.484 0.484
## year2020 -0.455 0.472 0.487 0.484 0.484 0.480

ggplot(PMdata, aes(x = year, y = PM.10Avr)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).

```



```
mod10timenullMM <- lmer(PM.10Avr ~ (1|code), PMdata)
anova(mod10timenullMM, mod10timeMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## mod10timenullMM: PM.10Avr ~ (1 | code)
## mod10timeMM: PM.10Avr ~ year + (1 | code)
##
```

	np	par	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
mod10timenullMM	3	-459.59	-451.99	232.80	-465.59				
mod10timeMM	9	-470.36	-447.56	244.18	-488.36	22.764	6	0.0008796	***

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#TSPAвр - увеличивается во времени
modTSPtime <- lm(TSPAвр ~ code + year, PMdata)
anova(modTSPtime)

## Analysis of Variance Table
##
## Response: TSPAвр
##
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
code	14	0.061016	0.0043583	8.1672	4.225e-10 ***
year	6	0.039954	0.0066590	12.4786	1.376e-09 ***
Residuals	72	0.038421	0.0005336		

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(modTSPtime)
```

```
##
## Call:
## lm(formula = TSPAver ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.049937 -0.015225  0.000583  0.014342  0.049754
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.1325820  0.0105041  12.622 < 2e-16 ***
## code2        -0.0672548  0.0162015  -4.151 8.96e-05 ***
## code3        -0.0586092  0.0136212  -4.303 5.23e-05 ***
## code4        -0.0742286  0.0123477  -6.012 6.91e-08 ***
## code5        -0.0569857  0.0123477  -4.615 1.67e-05 ***
## code6        -0.0491571  0.0123477  -3.981 0.000162 ***
## code7        -0.0309548  0.0162015  -1.911 0.060037 .
## code8        -0.0504000  0.0123477  -4.082 0.000114 ***
## code9        -0.0194000  0.0123477  -1.571 0.120535
## code10       0.0024286  0.0123477   0.197 0.844631
## code11       -0.0055286  0.0123477  -0.448 0.655685
## code12       -0.0229000  0.0123477  -1.855 0.067749 .
## code13       -0.0140429  0.0123477  -1.137 0.259190
## code14       -0.0356143  0.0123477  -2.884 0.005171 **
## code15       -0.0464944  0.0136149  -3.415 0.001052 **
## year2015     0.0008643  0.0087312   0.099 0.921422
## year2016     0.0343542  0.0086147   3.988 0.000158 ***
## year2017     0.0519205  0.0090497   5.737 2.11e-07 ***
## year2018     0.0344974  0.0090497   3.812 0.000288 ***
## year2019     0.0380616  0.0092820   4.101 0.000107 ***
## year2020     0.0605283  0.0092820   6.521 8.34e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0231 on 72 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.7244, Adjusted R-squared:  0.6478
## F-statistic: 9.461 on 20 and 72 DF, p-value: 3.81e-13

#точка как случайный эффект
modTSPtimeMM <- lmer(TSPAver ~ year + (1|code), PMdata)
anova(modTSPtimeMM)

## Analysis of Variance Table
##      npar  Sum Sq Mean Sq F value
## year    6 0.041574 0.006929  13.003

summary(modTSPtimeMM)

## Linear mixed model fit by REML ['lmerMod']
## Formula: TSPAver ~ year + (1 | code)
##      Data: PMdata
##
```

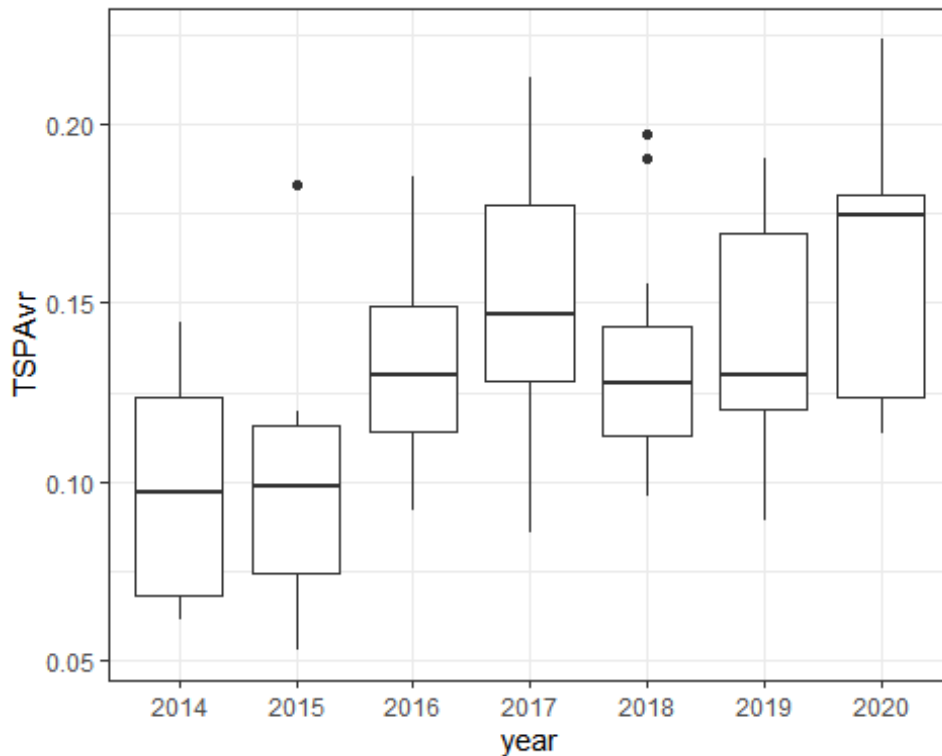
```

## REML criterion at convergence: -359.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.05299 -0.57375 -0.00661  0.62669  2.36138
##
## Random effects:
##   Groups   Name                Variance Std.Dev.
##   code     (Intercept)  0.0005233  0.02288
##   Residual                  0.0005329  0.02308
## Number of obs: 93, groups:  code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.0974078  0.0085662  11.371
## year2015     0.0008643  0.0087251   0.099
## year2016     0.0342522  0.0086034   3.981
## year2017     0.0523500  0.0090063   5.813
## year2018     0.0349269  0.0090063   3.878
## year2019     0.0388468  0.0092313   4.208
## year2020     0.0613135  0.0092313   6.642
##
## Correlation of Fixed Effects:
##              (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015    -0.509
## year2016    -0.522  0.507
## year2017    -0.501  0.484  0.498
## year2018    -0.501  0.484  0.498  0.495
## year2019    -0.489  0.473  0.487  0.483  0.483
## year2020    -0.489  0.473  0.487  0.483  0.483  0.479

ggplot(PMdata, aes(x = year, y = TSPAвр)) + geom_boxplot()

## Warning: Removed 12 rows containing non-finite values (stat_boxplot).

```



```
modTSPtimenullMM <- lmer(TSPAver ~ (1|code), PMdata)
anova(modTSPtimenullMM,modTSPtimeMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modTSPtimenullMM: TSPAver ~ (1 | code)
## modTSPtimeMM: TSPAver ~ year + (1 | code)
##
```

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
## modTSPtimenullMM	3	-350.85	-343.25	178.42	-356.85			
## modTSPtimeMM	9	-397.32	-374.52	207.66	-415.32	58.468	6	9.208e-11 **

```

*
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#PM2.5Max - Увеличивается во времени
mod25timeMax <- lm(PM.2.5Max ~ code + year, PMdata)
anova(mod25timeMax)

## Analysis of Variance Table
##
## Response: PM.2.5Max
##
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
## code	14	0.14059	0.0100421	3.4507	0.0002682 ***
## year	6	0.04289	0.0071484	2.4563	0.0322943 *
## Residuals	72	0.20953	0.0029102		

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
summary(mod25timeMax)
```

```
##
## Call:
## lm(formula = PM.2.5Max ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.096497 -0.031173 -0.006729  0.032420  0.215074
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.150158   0.024530   6.121 4.4e-08 ***
## code2        -0.072353   0.037835  -1.912 0.059812 .
## code3        -0.060356   0.031809  -1.897 0.061782 .
## code4        -0.115571   0.028835  -4.008 0.000148 ***
## code5        -0.116571   0.028835  -4.043 0.000131 ***
## code6        -0.051714   0.028835  -1.793 0.077104 .
## code7        -0.015353   0.037835  -0.406 0.686098
## code8        -0.075857   0.028835  -2.631 0.010415 *
## code9        -0.019143   0.028835  -0.664 0.508897
## code10        0.004714   0.028835   0.163 0.870591
## code11       -0.029143   0.028835  -1.011 0.315564
## code12       -0.007143   0.028835  -0.248 0.805063
## code13       -0.030286   0.028835  -1.050 0.297096
## code14       -0.028429   0.028835  -0.986 0.327489
## code15       -0.078680   0.031795  -2.475 0.015694 *
## year2015      0.003286   0.020390   0.161 0.872430
## year2016      0.046301   0.020118   2.302 0.024258 *
## year2017      0.037087   0.021134   1.755 0.083533 .
## year2018      0.031318   0.021134   1.482 0.142732
## year2019      0.061911   0.021676   2.856 0.005600 **
## year2020      0.053994   0.021676   2.491 0.015046 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05395 on 72 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.4669, Adjusted R-squared:  0.3188
## F-statistic: 3.152 on 20 and 72 DF, p-value: 0.0001864
```

#точка как случайный эффект

```
mod25timeMaxMM <- lmer(PM.2.5Max ~ year + (1|code), PMdata)
anova(mod25timeMaxMM)
```

```
## Analysis of Variance Table
##      npar  Sum Sq  Mean Sq F value
## year     6 0.04292 0.0071533  2.4731
```

```
summary(mod25timeMaxMM)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.2.5Max ~ year + (1 | code)
```

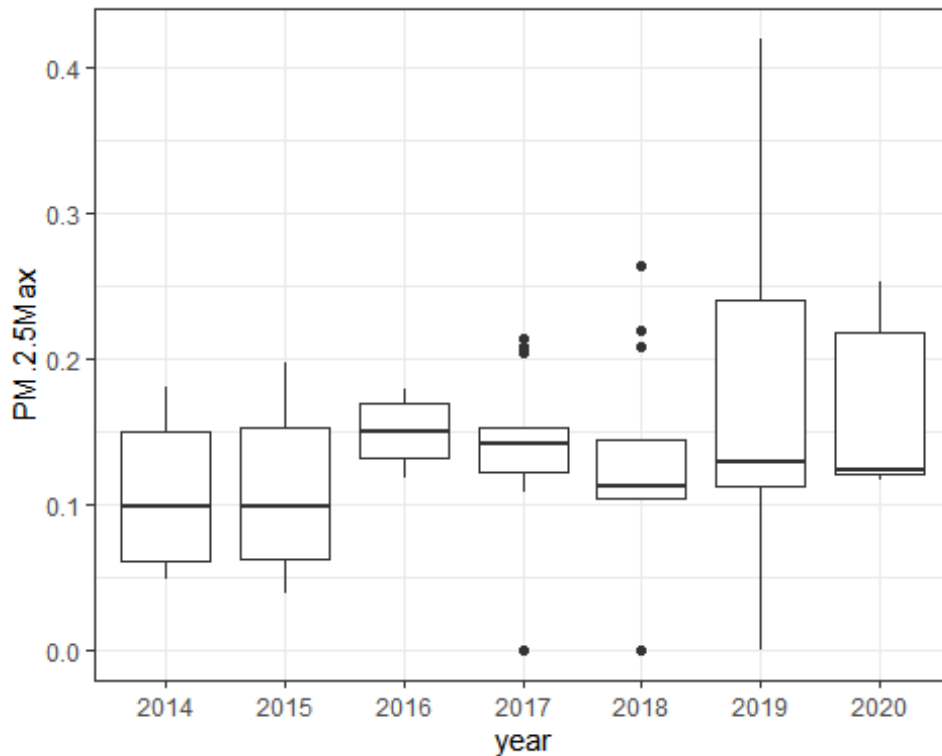
```

## Data: PMdata
##
## REML criterion at convergence: -223.7
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.1398 -0.5507 -0.1544  0.6310  4.1953
##
## Random effects:
## Groups Name Variance Std.Dev.
## code (Intercept) 0.001125 0.03354
## Residual 0.002892 0.05378
## Number of obs: 93, groups: code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) 0.104550 0.016835 6.210
## year2015 0.003286 0.020327 0.162
## year2016 0.045517 0.020032 2.272
## year2017 0.036078 0.020911 1.725
## year2018 0.030309 0.020911 1.449
## year2019 0.061267 0.021418 2.861
## year2020 0.053350 0.021418 2.491
##
## Correlation of Fixed Effects:
##      (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015 -0.604
## year2016 -0.618 0.507
## year2017 -0.593 0.486 0.499
## year2018 -0.593 0.486 0.499 0.491
## year2019 -0.580 0.475 0.487 0.480 0.480
## year2020 -0.580 0.475 0.487 0.480 0.480 0.475

ggplot(PMdata, aes(x = year, y = PM.2.5Max)) + geom_boxplot()

## Warning: Removed 12 rows containing non-finite values (stat_boxplot).

```

```
mod25timenullMaxMM <- lmer(PM.2.5Max ~ (1|code), PMdata)
anova(mod25timenullMaxMM, mod25timeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## mod25timenullMaxMM: PM.2.5Max ~ (1 | code)
## mod25timeMaxMM: PM.2.5Max ~ year + (1 | code)
##
```

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
## mod25timenullMaxMM	3	-248.22	-240.62	127.11	-254.22			
## mod25timeMaxMM	9	-250.84	-228.05	134.42	-268.84	14.618	6	0.02344

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#PM10Max - Увеличивается во времени
mod10timeMax <- lm(PM.10Max ~ code + year, PMdata)
anova(mod10timeMax)

## Analysis of Variance Table
##
## Response: PM.10Max
##
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
## code	14	0.42556	0.0303969	4.4841	1.029e-05 ***
## year	6	0.09692	0.0161535	2.3829	0.03717 *
## Residuals	72	0.48808	0.0067789		

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(mod10timeMax)
```

```
##
## Call:
## lm(formula = PM.10Max ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.145460 -0.063684  0.006338  0.057909  0.157445
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.311856   0.037438   8.330 3.71e-12 ***
## code2       -0.169887   0.057745  -2.942 0.004384 **
## code3       -0.141883   0.048548  -2.923 0.004637 **
## code4       -0.210000   0.044009  -4.772 9.30e-06 ***
## code5       -0.185143   0.044009  -4.207 7.36e-05 ***
## code6       -0.116571   0.044009  -2.649 0.009921 **
## code7       -0.051220   0.057745  -0.887 0.378026
## code8       -0.160571   0.044009  -3.649 0.000496 ***
## code9       -0.072286   0.044009  -1.643 0.104845
## code10      -0.001429   0.044009  -0.032 0.974194
## code11      -0.019143   0.044009  -0.435 0.664883
## code12      -0.057286   0.044009  -1.302 0.197178
## code13      -0.062000   0.044009  -1.409 0.163200
## code14      -0.065571   0.044009  -1.490 0.140607
## code15      -0.147515   0.048526  -3.040 0.003298 **
## year2015    -0.001286   0.031119  -0.041 0.967159
## year2016     0.076377   0.030704   2.488 0.015181 *
## year2017     0.079713   0.032254   2.471 0.015826 *
## year2018     0.057328   0.032254   1.777 0.079732 .
## year2019     0.073603   0.033083   2.225 0.029227 *
## year2020     0.062270   0.033083   1.882 0.063843 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.08233 on 72 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.517, Adjusted R-squared:  0.3829
## F-statistic: 3.854 on 20 and 72 DF, p-value: 1.253e-05
```

#точка как случайный эффект

```
mod10timeMaxMM <- lmer(PM.10Max ~ year + (1|code), PMdata, na.action=na.omit)
anova(mod10timeMaxMM)
```

```
## Analysis of Variance Table
##      npar  Sum Sq Mean Sq F value
## year     6 0.098592 0.016432  2.4322
```

```
summary(mod10timeMaxMM)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: PM.10Max ~ year + (1 | code)
```

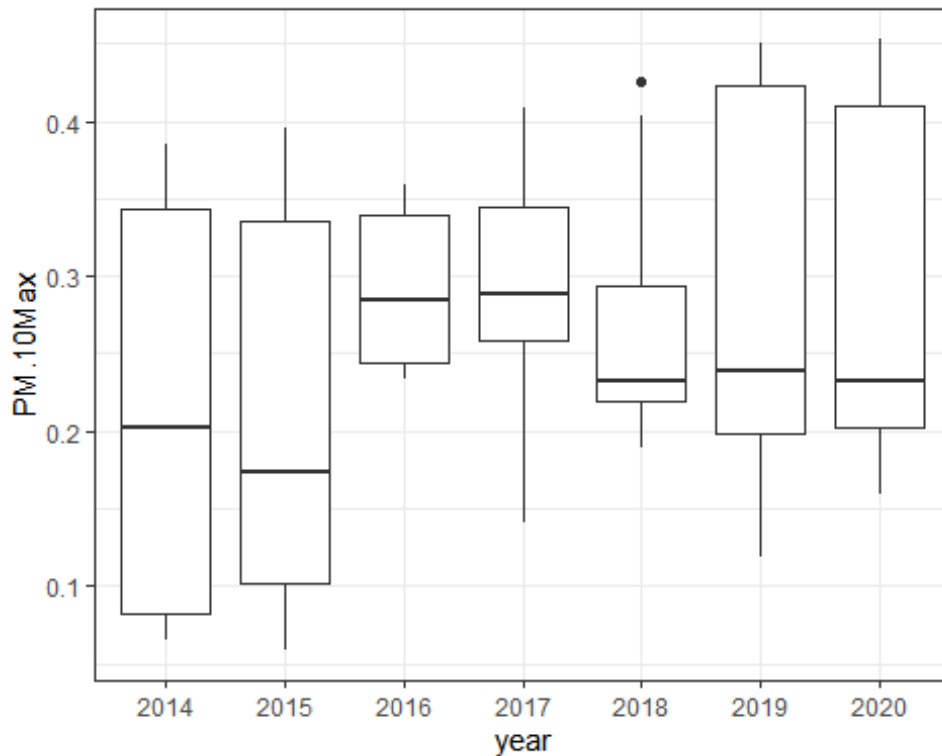
```

## Data: PMdata
##
## REML criterion at convergence: -147.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.53556 -0.79207 -0.06645  0.75811  1.89058
##
## Random effects:
## Groups Name Variance Std.Dev.
## code (Intercept) 0.003684 0.0607
## Residual 0.006756 0.0822
## Number of obs: 93, groups: code, 15
##
## Fixed effects:
## Estimate Std. Error t value
## (Intercept) 0.215400 0.027073 7.956
## year2015 -0.001286 0.031067 -0.041
## year2016 0.075467 0.030623 2.464
## year2017 0.079514 0.032002 2.485
## year2018 0.057129 0.032002 1.785
## year2019 0.074420 0.032788 2.270
## year2020 0.063086 0.032788 1.924
##
## Correlation of Fixed Effects:
## (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015 -0.574
## year2016 -0.588 0.507
## year2017 -0.564 0.485 0.499
## year2018 -0.564 0.485 0.499 0.493
## year2019 -0.551 0.474 0.487 0.481 0.481
## year2020 -0.551 0.474 0.487 0.481 0.481 0.476

ggplot(PMdata, aes(x = year, y = PM.10Max)) + geom_boxplot()

## Warning: Removed 12 rows containing non-finite values (stat_boxplot).

```



```
mod10timenullMaxMM <- lmer(PM.10Max ~ (1|code), PMdata)
anova(mod10timenullMaxMM, mod10timeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## mod10timenullMaxMM: PM.10Max ~ (1 | code)
## mod10timeMaxMM: PM.10Max ~ year + (1 | code)
##
```

	npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
## mod10timenullMaxMM	3	-165.82	-158.22	85.909	-171.82			
## mod10timeMaxMM	9	-168.24	-145.45	93.121	-186.24	14.424	6	0.02524

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#TSPMax - Не меняется во времени
modTSPtimeMax <- lm(TSPMax ~ code + year, PMdata)
anova(modTSPtimeMax)

## Analysis of Variance Table
##
## Response: TSPMax
##
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
## code	14	1.09042	0.077887	4.9210	2.734e-06 ***
## year	6	0.09984	0.016639	1.0513	0.3999
## Residuals	72	1.13957	0.015827		

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(modTSPtimeMax)

##
## Call:
## lm(formula = TSPMax ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.29448 -0.07543  0.02052  0.07838  0.20489
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.56362    0.05721   9.852 5.51e-15 ***
## code2        -0.29032    0.08823  -3.290 0.001551 **
## code3        -0.18598    0.07418  -2.507 0.014431 *
## code4        -0.34014    0.06725  -5.058 3.12e-06 ***
## code5        -0.25557    0.06725  -3.801 0.000299 ***
## code6        -0.12457    0.06725  -1.852 0.068060 .
## code7        -0.03899    0.08823  -0.442 0.659927
## code8        -0.11014    0.06725  -1.638 0.105808
## code9        -0.07671    0.06725  -1.141 0.257738
## code10       0.03357    0.06725   0.499 0.619141
## code11       -0.02029    0.06725  -0.302 0.763780
## code12       -0.06057    0.06725  -0.901 0.370733
## code13       -0.04600    0.06725  -0.684 0.496141
## code14       -0.09600    0.06725  -1.428 0.157736
## code15       -0.23869    0.07415  -3.219 0.001929 **
## year2015     0.02129    0.04755   0.448 0.655755
## year2016     0.06980    0.04692   1.488 0.141155
## year2017     0.05823    0.04929   1.182 0.241283
## year2018     0.02746    0.04929   0.557 0.579110
## year2019     0.07880    0.05055   1.559 0.123400
## year2020     0.10405    0.05055   2.058 0.043170 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1258 on 72 degrees of freedom
## (12 observations deleted due to missingness)
## Multiple R-squared:  0.5109, Adjusted R-squared:  0.375
## F-statistic:  3.76 on 20 and 72 DF,  p-value: 1.785e-05

#точка как случайный эффект
modTSPtimeMaxMM <- lmer(TSPMax ~ year + (1|code), PMdata)
anova(modTSPtimeMaxMM)

## Analysis of Variance Table
##      npar  Sum Sq Mean Sq F value
## year     6 0.10304 0.017174  1.0848

summary(modTSPtimeMaxMM)

## Linear mixed model fit by REML ['lmerMod']
## Formula: TSPMax ~ year + (1 | code)
```

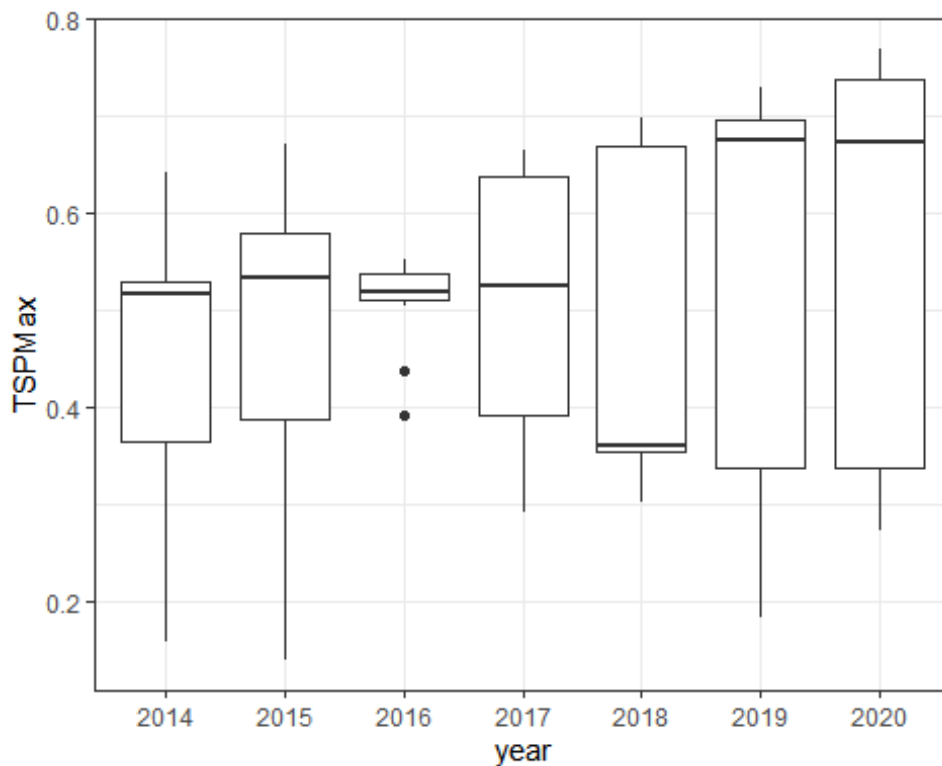
```

## Data: PMdata
##
## REML criterion at convergence: -72.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.3222 -0.6625  0.1644  0.7169  1.6132
##
## Random effects:
## Groups Name Variance Std.Dev.
## code (Intercept) 0.01000 0.1000
## Residual 0.01583 0.1258
## Number of obs: 93, groups: code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) 0.44212 0.04254 10.394
## year2015 0.02129 0.04756 0.448
## year2016 0.06794 0.04688 1.449
## year2017 0.05844 0.04902 1.192
## year2018 0.02767 0.04902 0.564
## year2019 0.08034 0.05023 1.600
## year2020 0.10559 0.05023 2.102
##
## Correlation of Fixed Effects:
##      (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015 -0.559
## year2016 -0.573 0.507
## year2017 -0.550 0.485 0.499
## year2018 -0.550 0.485 0.499 0.493
## year2019 -0.537 0.473 0.487 0.482 0.482
## year2020 -0.537 0.473 0.487 0.482 0.482 0.477

ggplot(PMdata, aes(x = year, y = TSPMax)) + geom_boxplot()

## Warning: Removed 12 rows containing non-finite values (stat_boxplot).

```



```
modTSPtimenullMaxMM <- lmer(TSPMax ~ (1|code), PMdata)
anova(modTSPtimenullMaxMM, modTSPtimeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modTSPtimenullMaxMM: TSPMax ~ (1 | code)
## modTSPtimeMaxMM: TSPMax ~ year + (1 | code)
##
```

	np	par	AIC	BIC	loglik	deviance	Chisq	Df	Pr(>Chisq)
## modTSPtimenullMaxMM	3	-92.574	-84.977	49.287	-98.574				
## modTSPtimeMaxMM	9	-87.334	-64.540	52.667	-105.334	6.7594	6	0.3437	

```
##Визуализация депонированных доз по мониторинговым точкам и годам##

DD_code_visualcd <- function(x) {
  ggplot(PMdata, aes(x, y = code, color = year)) +
    geom_point() +
    geom_smooth(se = TRUE, method = "lm", size = 1)
  ggplot(PMdata, aes(x, y = code, color = code)) +
    geom_point() +
    geom_smooth(se = TRUE, method = "lm", size = 1)
}

DD_code_visualyrs <- function(x) {
  ggplot(PMdata, aes(x, y = year, color = code)) +
    geom_point() +
    geom_smooth(se = TRUE, method = "lm", size = 1)
  ggplot(PMdata, aes(x, y = year, color = year)) +
```

```

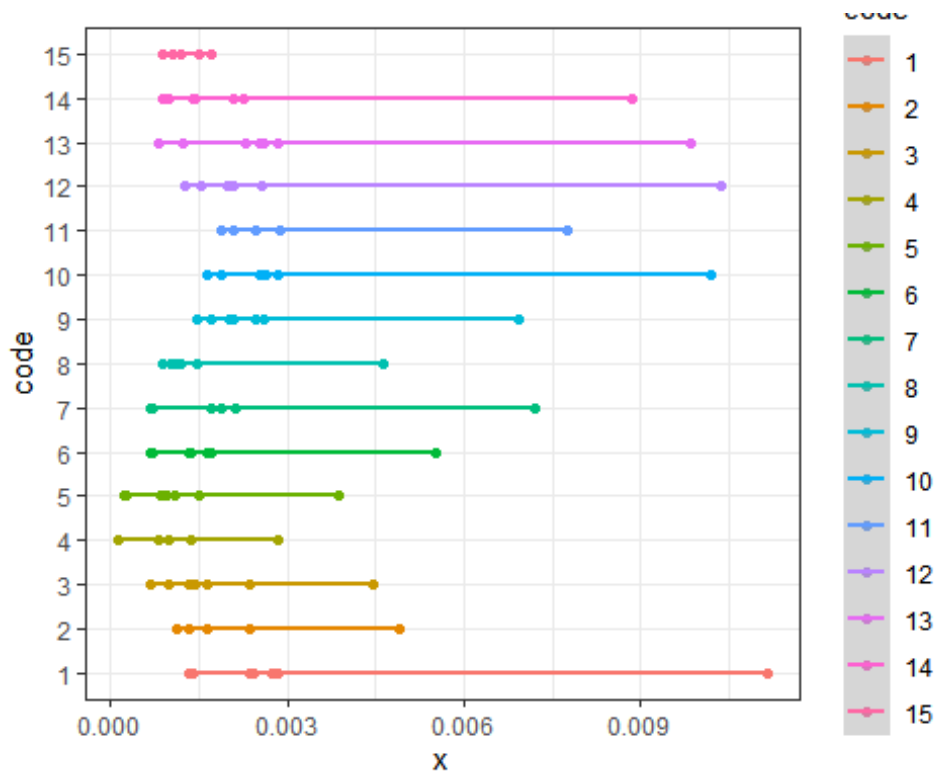
    geom_point() +
    geom_smooth(se = TRUE, method = "lm", size = 1)
}

DD <- list(PMdata$TBLogAvr, PMdata$TBPLogAvr, PMdata$PLogAvr, PMdata$TBAvr,
           PMdata$TBPAvr, PMdata$PAvr, PMdata$TBLogMax, PMdata$TBPLogMax, PMdata$PLogMax,
           PMdata$TBMax, PMdata$TBPMax, PMdata$PMax)
names(DD) <- list("TBLogAvr", "TBPLogAvr", "PLogAvr", "TBAvr",
                  "TBPAvr", "PAvr", "TBLogMax", "TBPLogMax", "PLogMax",
                  "TBMax", "TBPMax", "PMax")

lapply (DD, DD_code_visualcd)

## $TBLogAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 7 rows containing non-finite values (stat_smooth).
## Warning: Removed 7 rows containing missing values (geom_point).

```



```

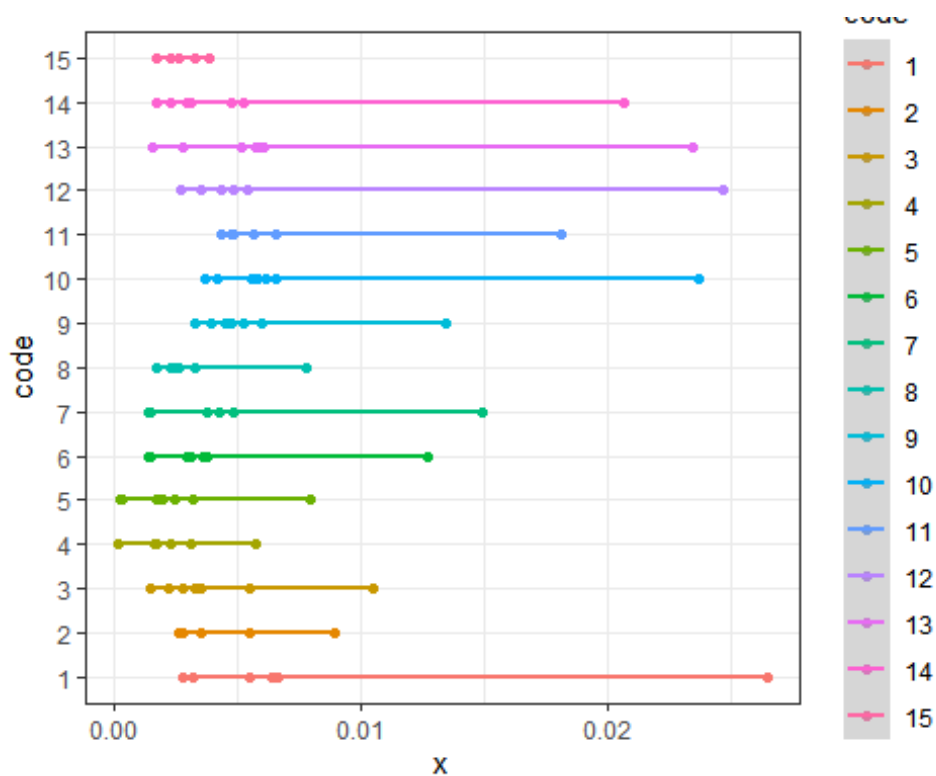
##
## $TBPLogAvr
## `geom_smooth()` using formula 'y ~ x'

```



```
## Warning: Removed 7 rows containing non-finite values (stat_smooth).
```

```
## Warning: Removed 7 rows containing missing values (geom_point).
```



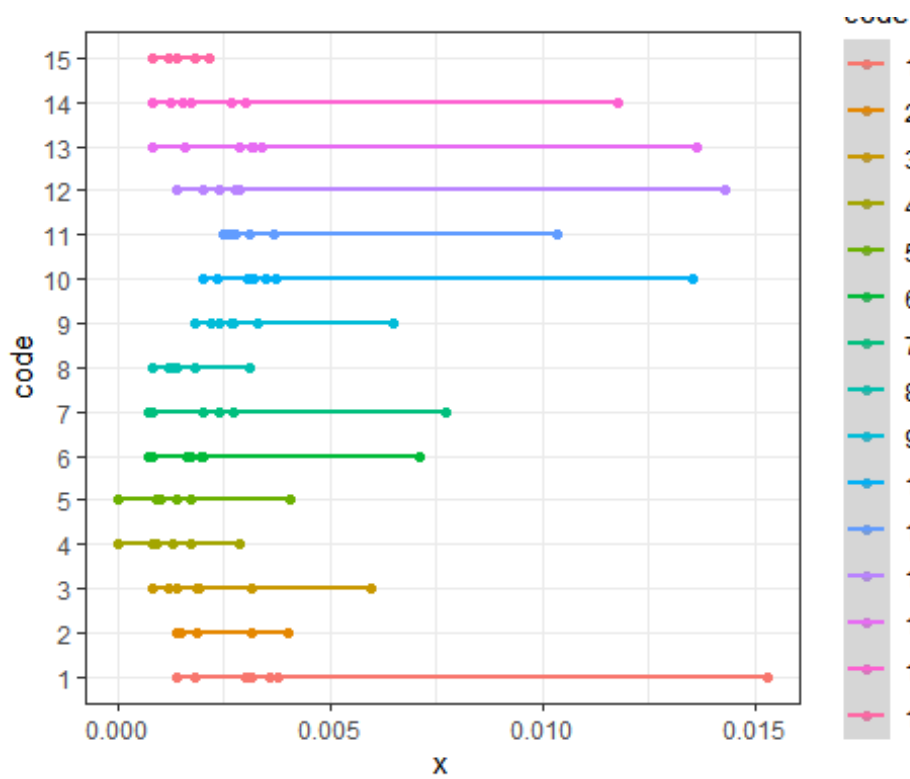
```
##
```

```
## $PLogAvr
```

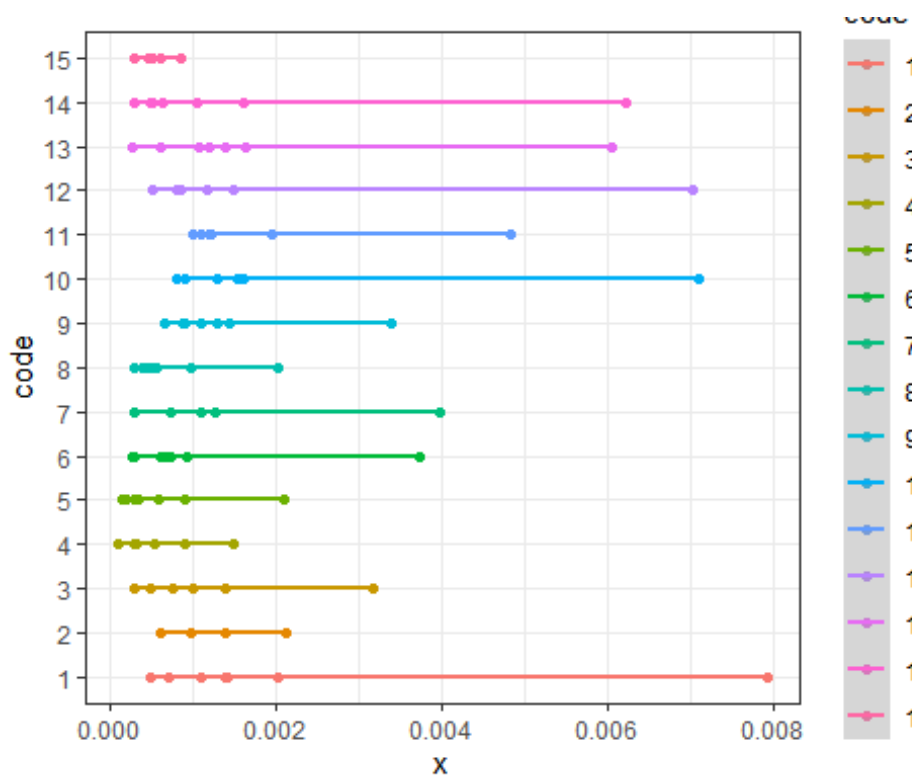
```
## `geom_smooth()` using formula 'y ~ x'
```

```
## Warning: Removed 7 rows containing non-finite values (stat_smooth).
```

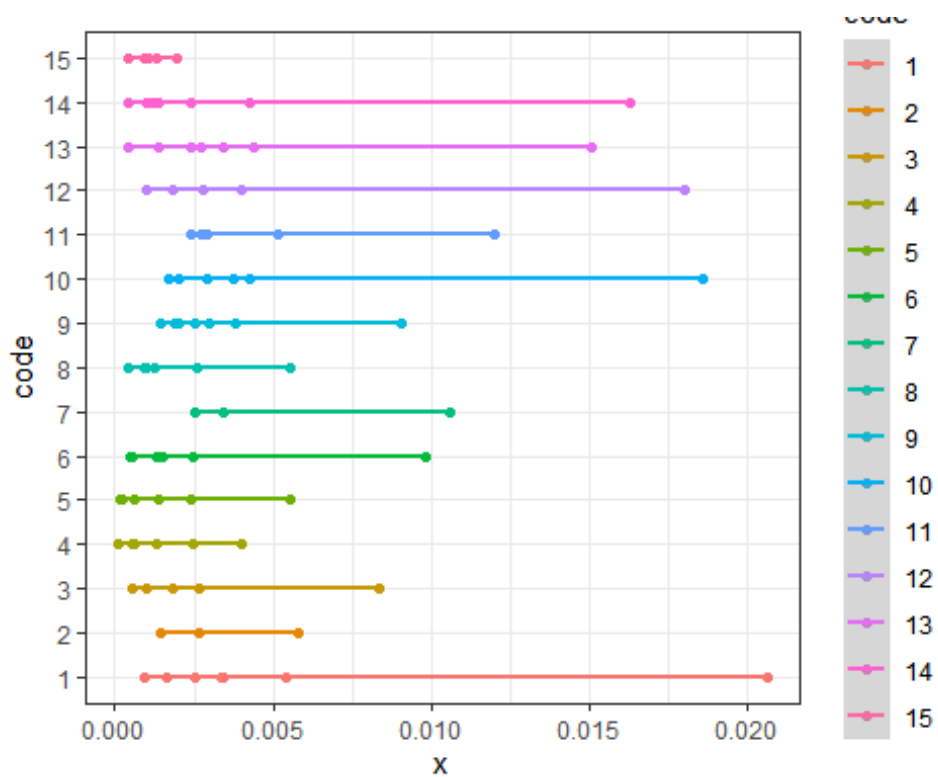
```
## Warning: Removed 7 rows containing missing values (geom_point).
```



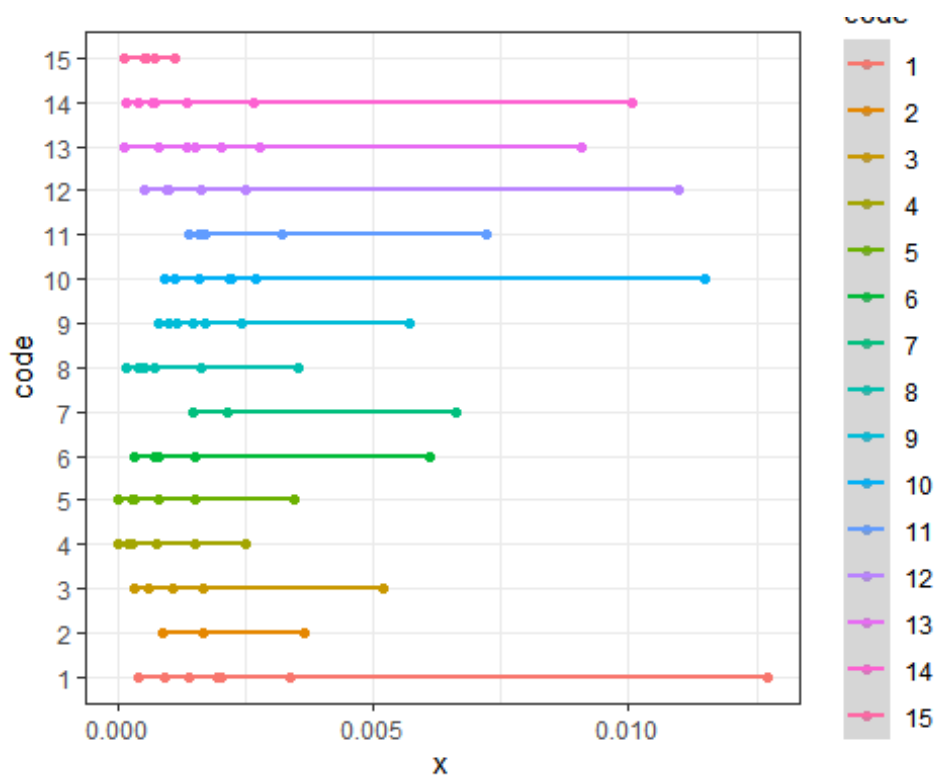
```
##
## $TBAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 10 rows containing non-finite values (stat_smooth).
## Warning: Removed 10 rows containing missing values (geom_point).
```



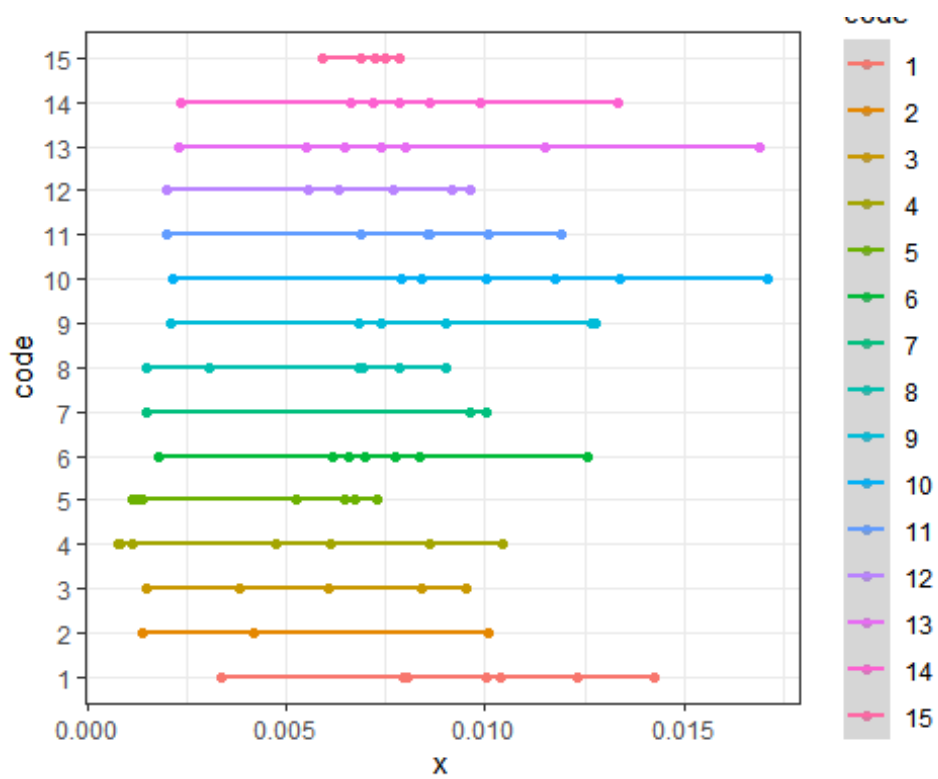
```
##
## $TBPAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 14 rows containing non-finite values (stat_smooth).
## Warning: Removed 14 rows containing missing values (geom_point).
```



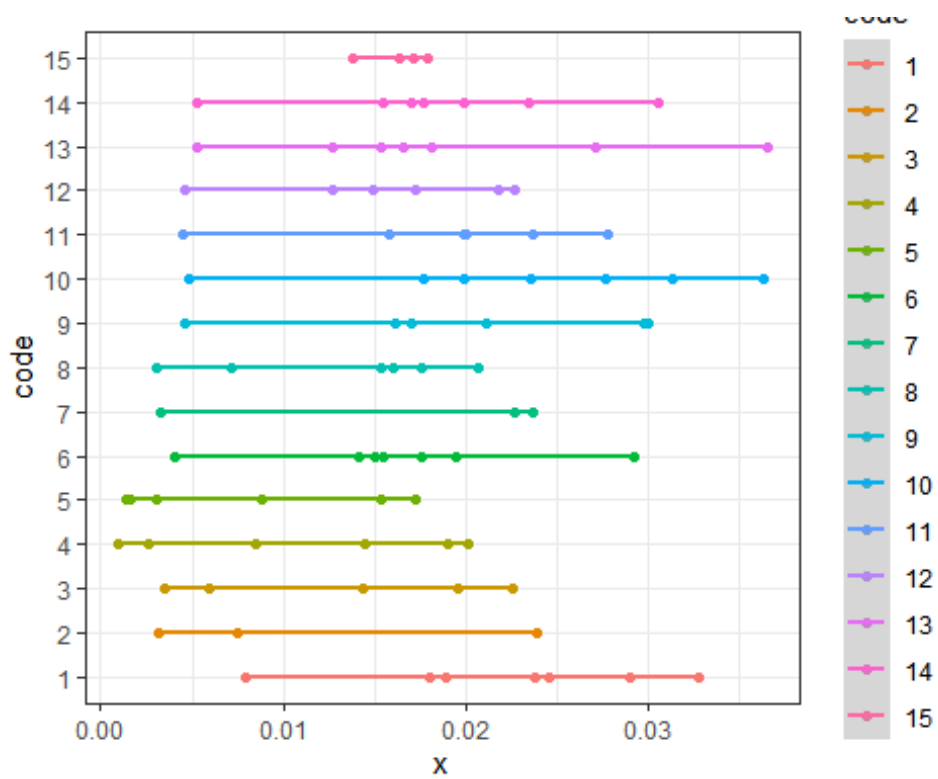
```
##
## $PAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 14 rows containing non-finite values (stat_smooth).
## Warning: Removed 14 rows containing missing values (geom_point).
```



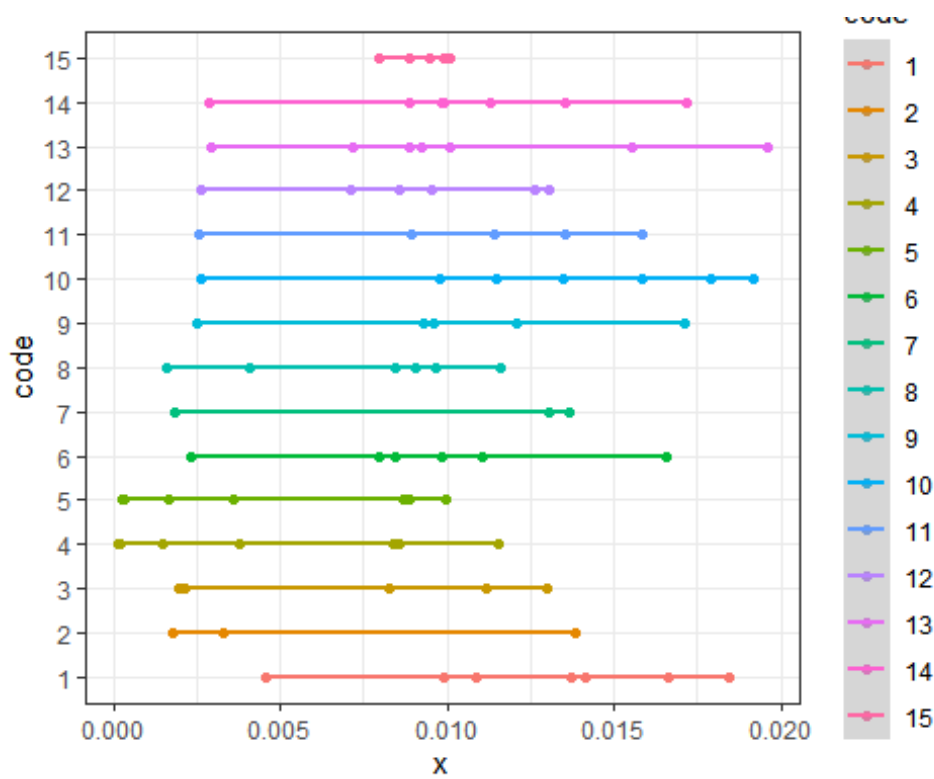
```
##
## $TBLogMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



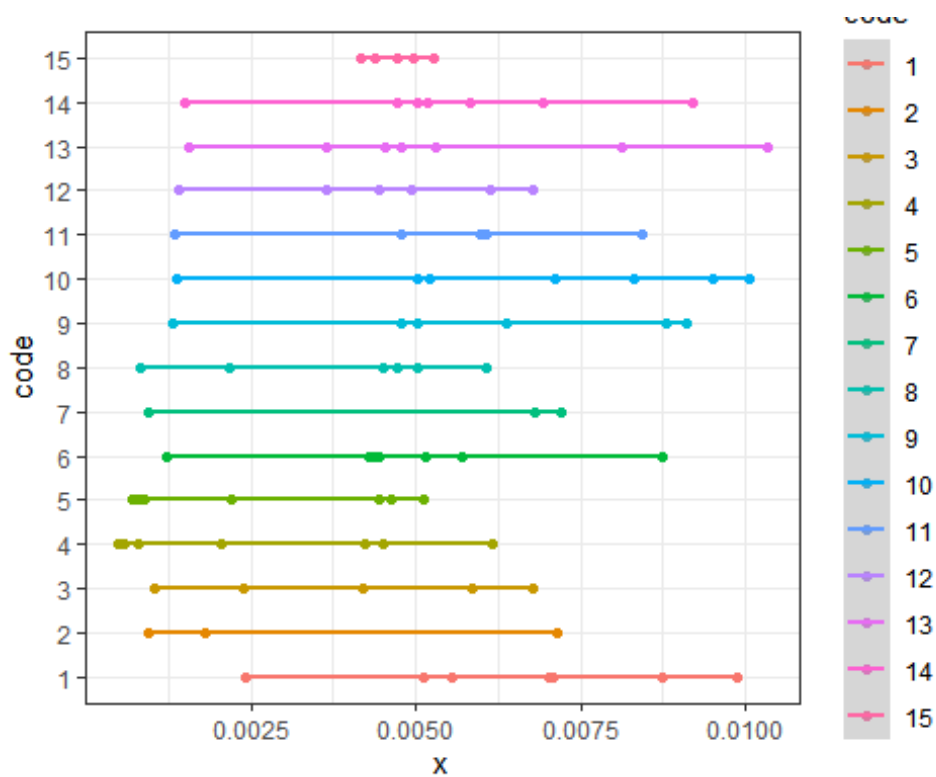
```
##
## $TBPLogMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



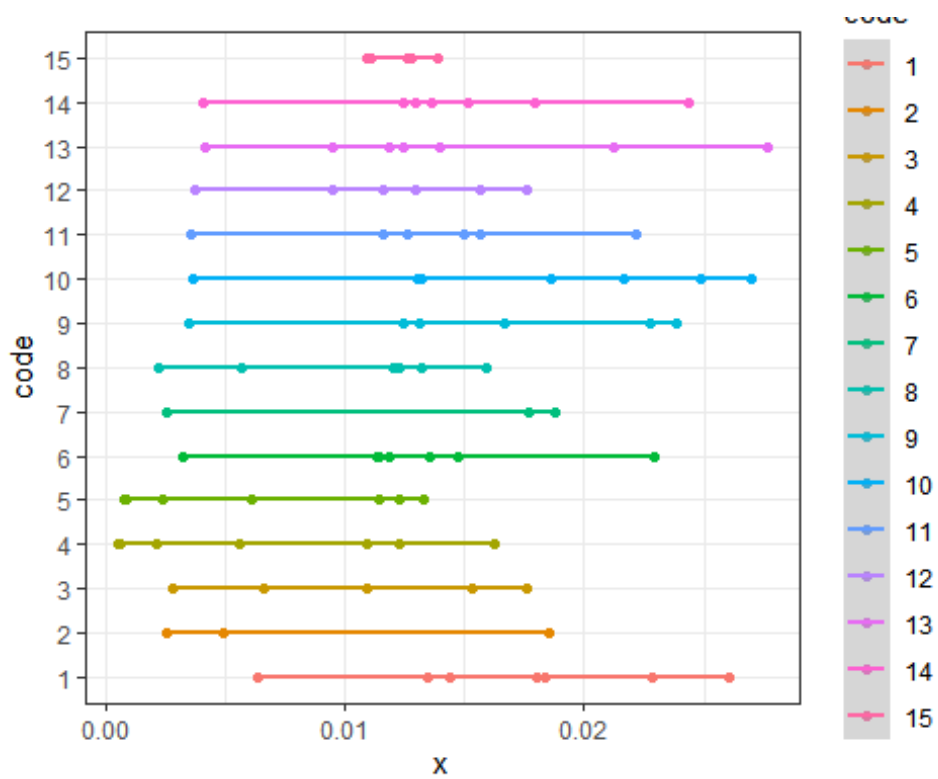
```
##
## $PLogMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



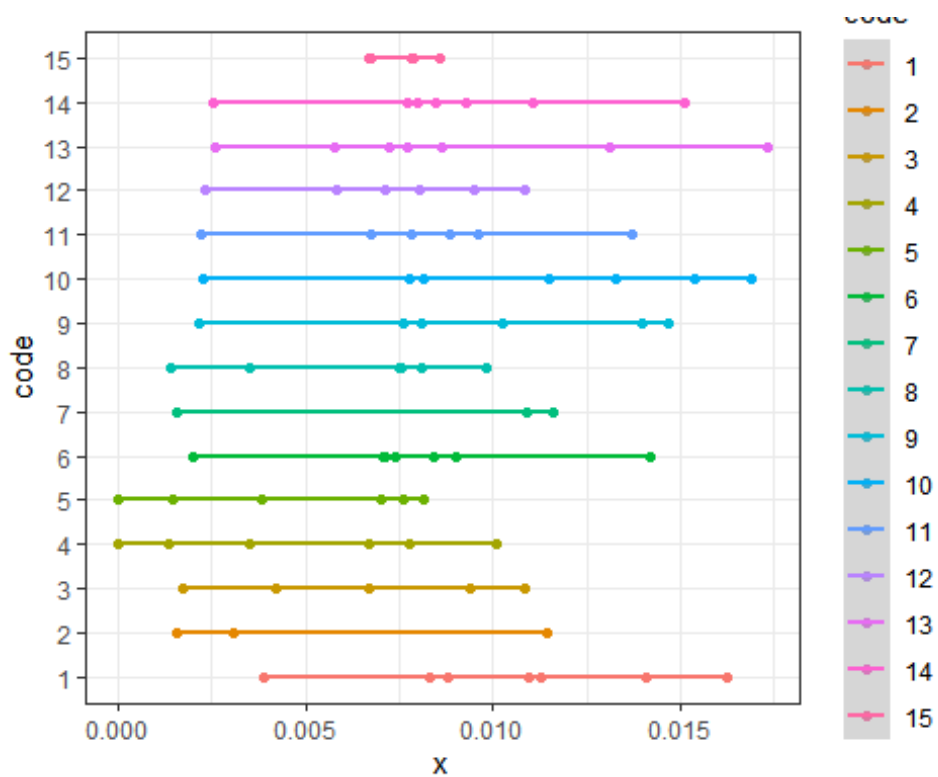
```
##
## $TbMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```

```
##
## $TBPMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



```
##
## $PMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



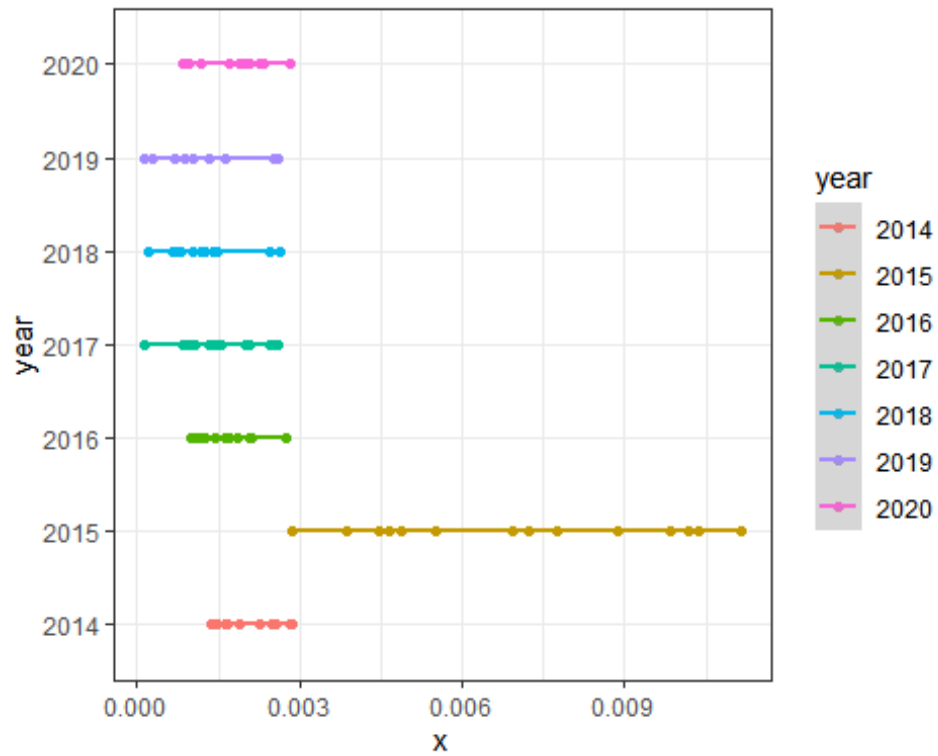
```
lapply (DD, DD_code_visualyrs)

## $TBlogAvr

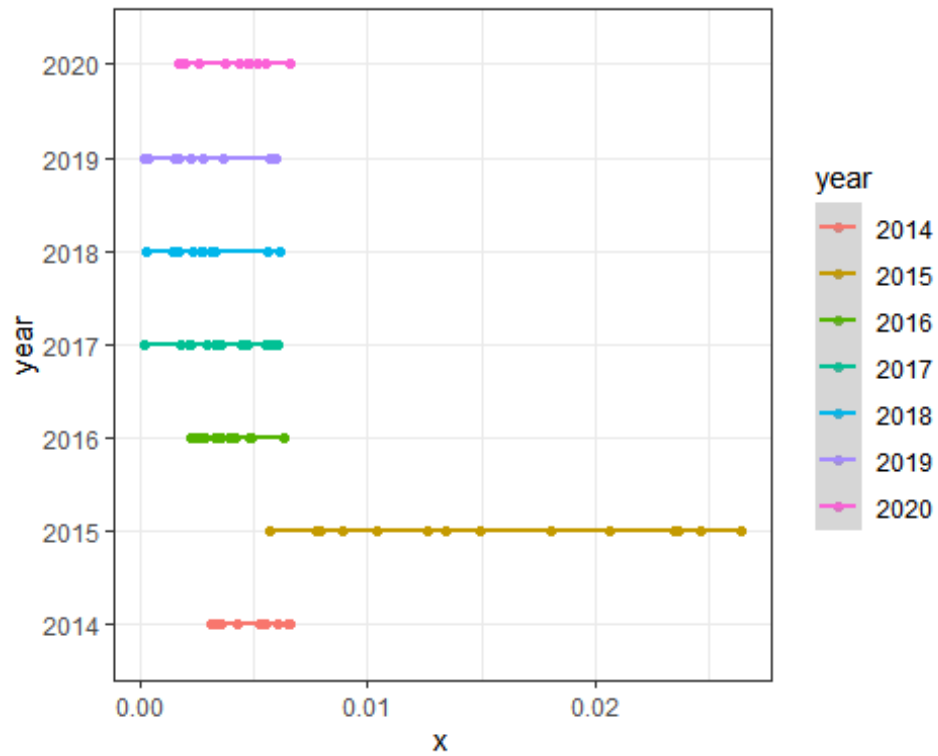
## `geom_smooth()` using formula 'y ~ x'

## Warning: Removed 7 rows containing non-finite values (stat_smooth).

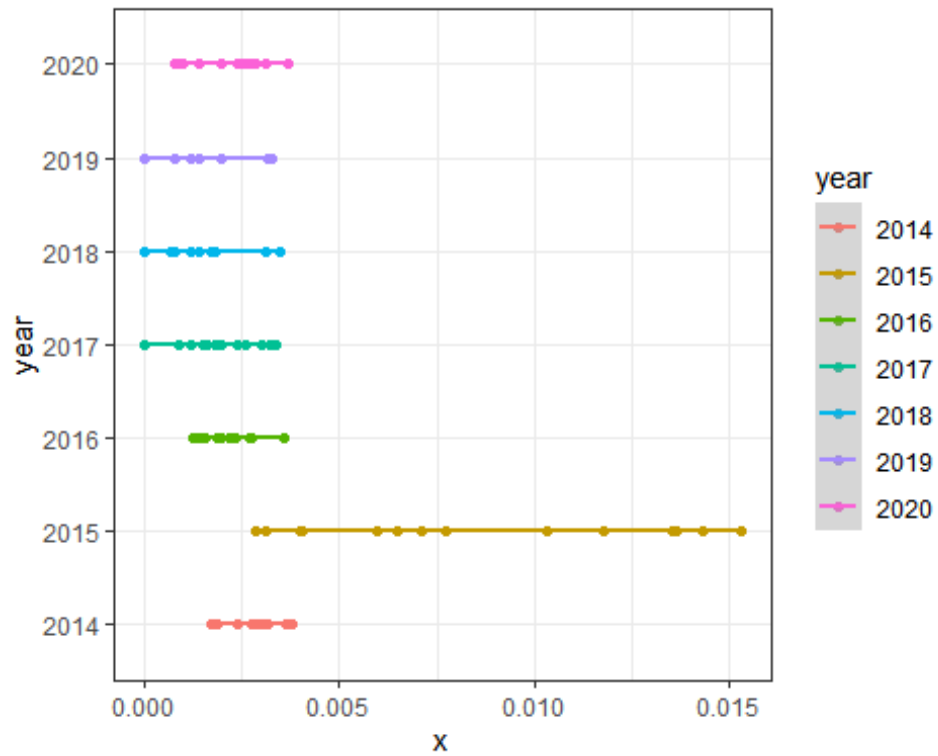
## Warning: Removed 7 rows containing missing values (geom_point).
```



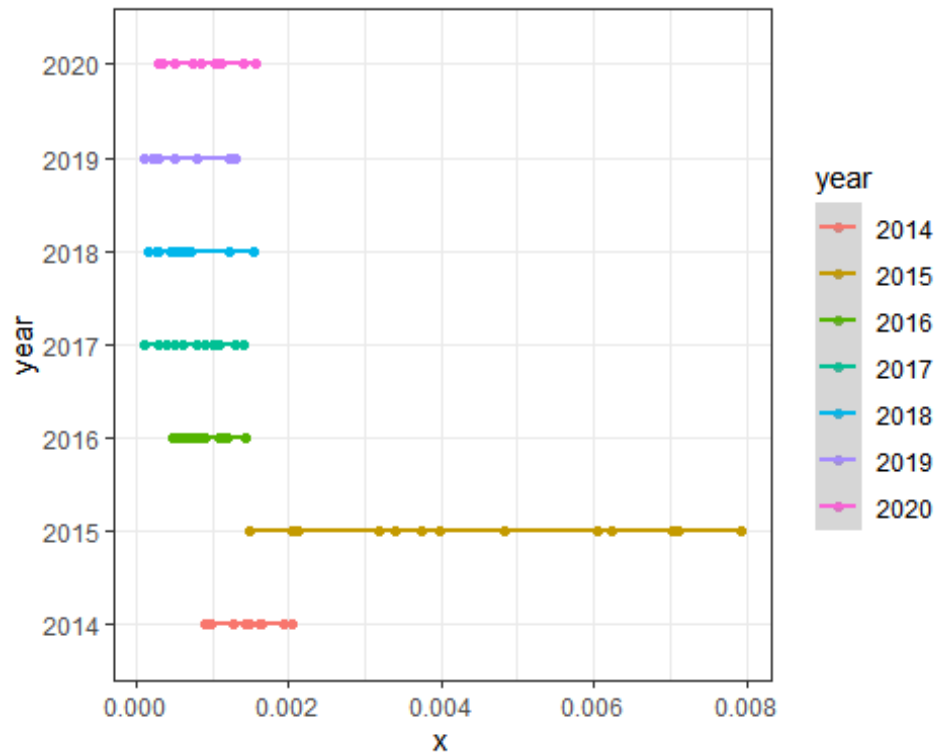
```
##
## $TBPLogAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 7 rows containing non-finite values (stat_smooth).
## Warning: Removed 7 rows containing missing values (geom_point).
```



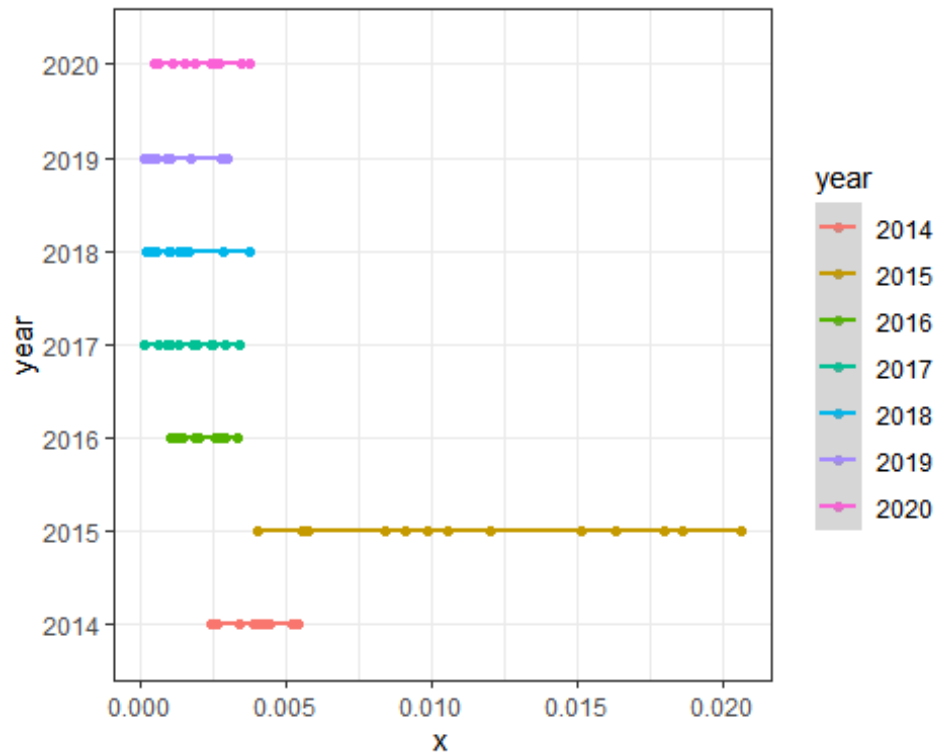
```
##
## $PLogAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 7 rows containing non-finite values (stat_smooth).
## Warning: Removed 7 rows containing missing values (geom_point).
```



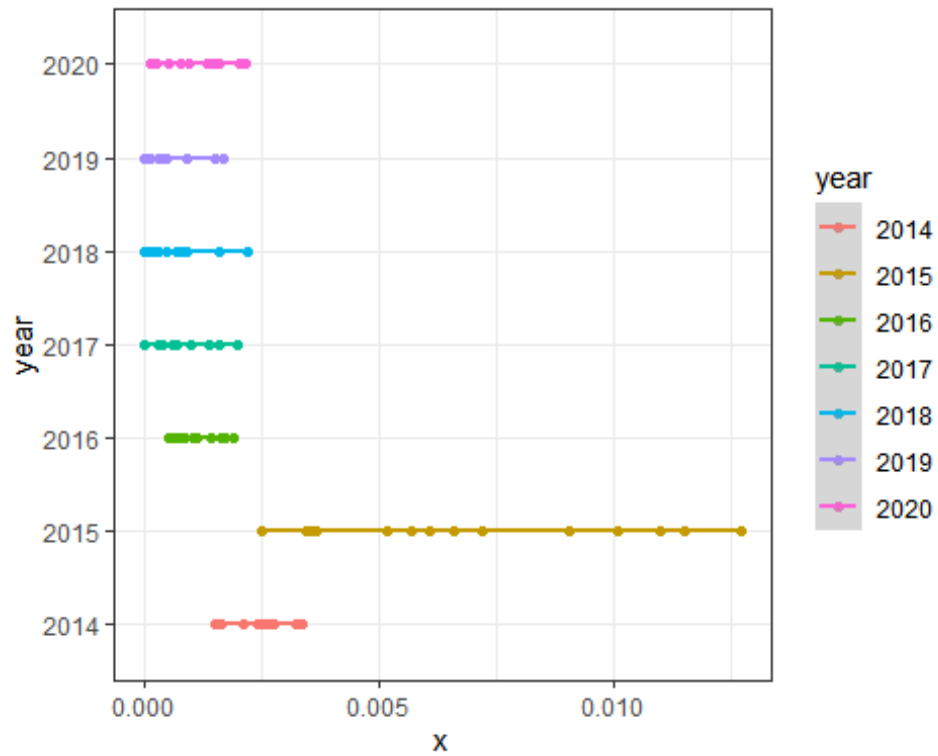
```
##  
## $TBAvr  
## `geom_smooth()` using formula 'y ~ x'  
## Warning: Removed 10 rows containing non-finite values (stat_smooth).  
## Warning: Removed 10 rows containing missing values (geom_point).
```



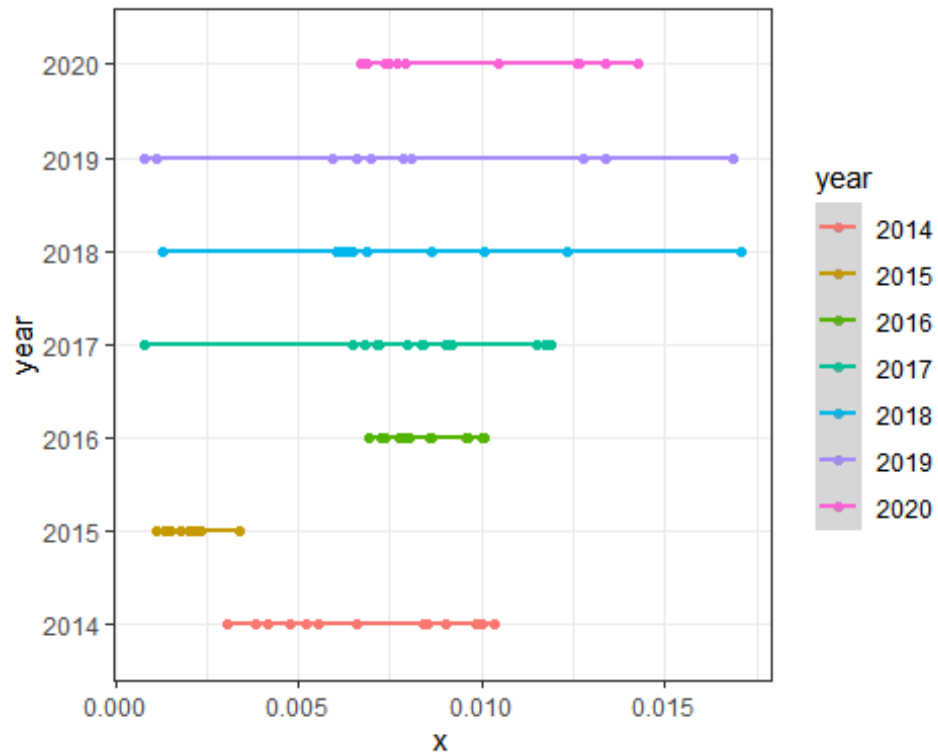
```
##  
## $TBPAvr  
## `geom_smooth()` using formula 'y ~ x'  
## Warning: Removed 14 rows containing non-finite values (stat_smooth).  
## Warning: Removed 14 rows containing missing values (geom_point).
```



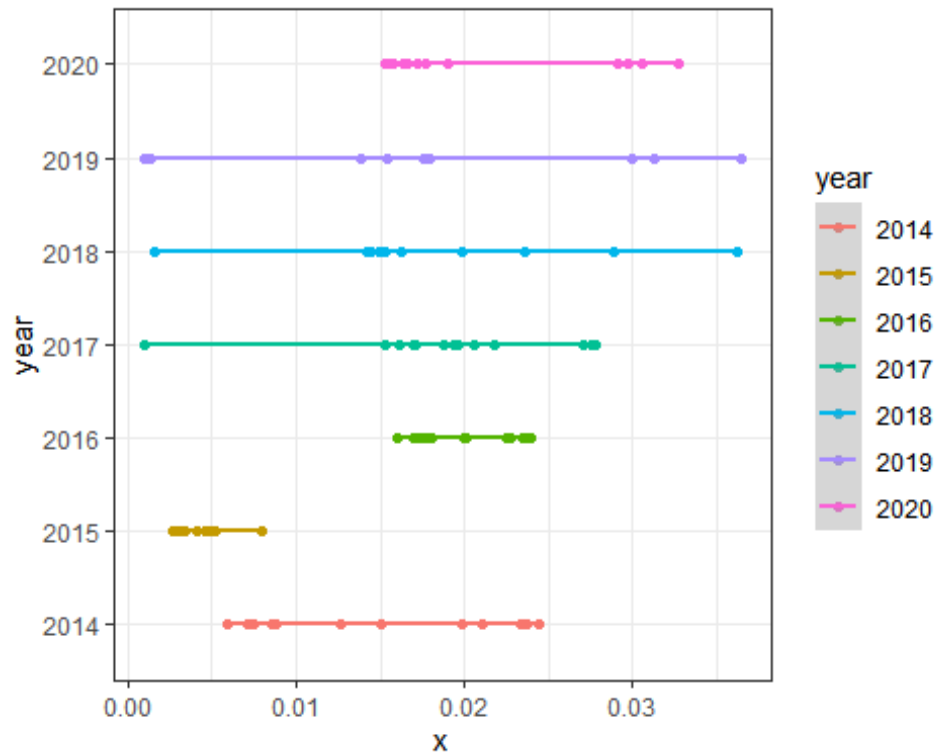
```
##
## $PAvr
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 14 rows containing non-finite values (stat_smooth).
## Warning: Removed 14 rows containing missing values (geom_point).
```

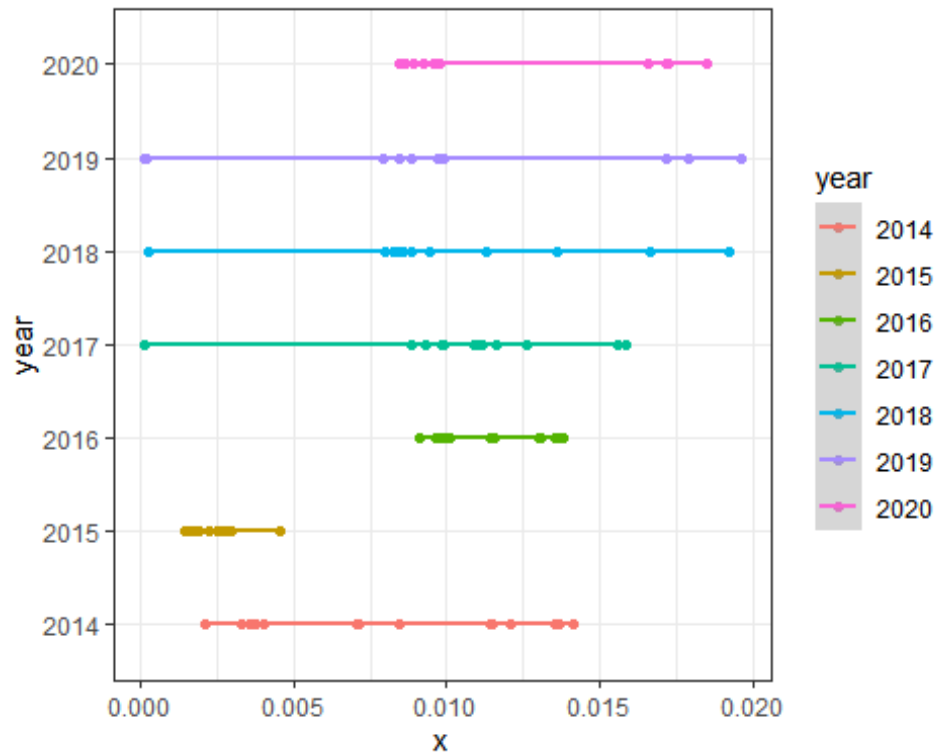
```
##  
## $TBLogMax  
## `geom_smooth()` using formula 'y ~ x'  
## Warning: Removed 16 rows containing non-finite values (stat_smooth).  
## Warning: Removed 16 rows containing missing values (geom_point).
```



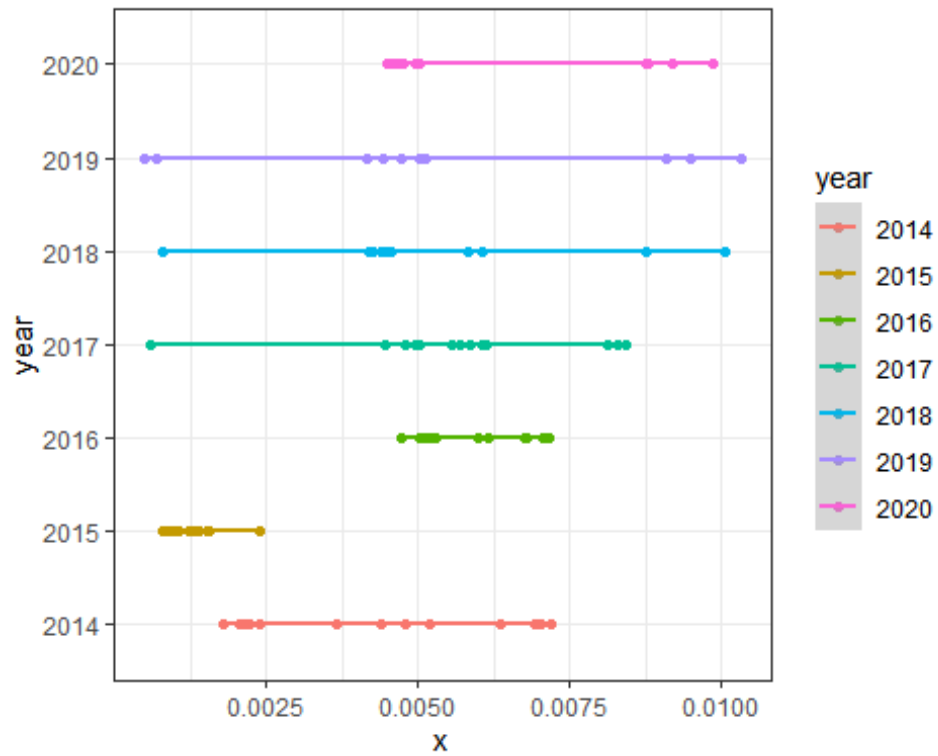
```
##  
## $TBPLogMax  
## `geom_smooth()` using formula 'y ~ x'  
## Warning: Removed 16 rows containing non-finite values (stat_smooth).  
## Warning: Removed 16 rows containing missing values (geom_point).
```



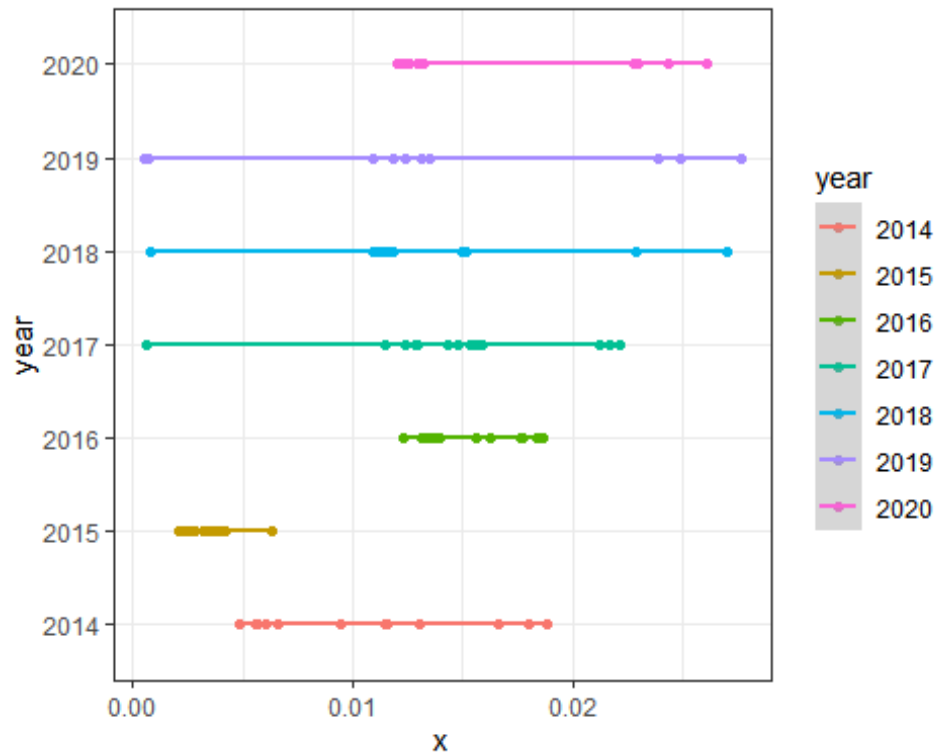
```
##
## $PLogMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



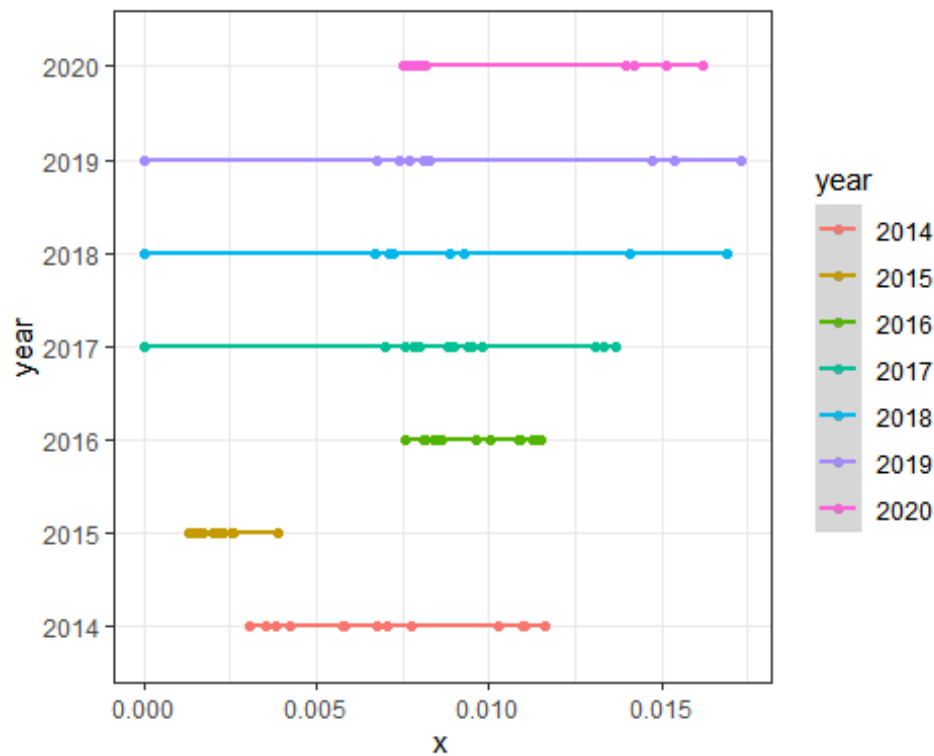
```
##
## $TBMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



```
##
## $TBPMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



```
##
## $PMax
## `geom_smooth()` using formula 'y ~ x'
## Warning: Removed 16 rows containing non-finite values (stat_smooth).
## Warning: Removed 16 rows containing missing values (geom_point).
```



#Увеличивается величина депонированных доз

#TBLogMax - увеличивается во времени

```
modTBLogtimeMax <- lm(TBLogMax ~ code + year, PMdata)
anova(modTBLogtimeMax)
```

```
## Analysis of Variance Table
```

```
##
```

```
## Response: TBLogMax
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
code	14	0.00026145	1.8675e-05	2.8527	0.002038 **
year	6	0.00051505	8.5842e-05	13.1129	8.485e-10 ***
Residuals	68	0.00044515	6.5460e-06		

```
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(modTBLogtimeMax)
```

```
##
```

```
## Call:
```

```
## lm(formula = TBLogMax ~ code + year, data = PMdata)
```

```
##
```

```
## Residuals:
```

	Min	1Q	Median	3Q	Max
Residuals	-0.0048316	-0.0014683	0.0000132	0.0014916	0.0077833

```
##
```

```
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.0088774	0.0011657	7.616	1.09e-10 ***
code2	-0.0026813	0.0017958	-1.493	0.140041
code3	-0.0030099	0.0015097	-1.994	0.050201 .

```

## code4      -0.0048177  0.0013676  -3.523  0.000768 ***
## code5      -0.0052706  0.0013676  -3.854  0.000260 ***
## code6      -0.0023036  0.0013676  -1.684  0.096697 .
## code7      -0.0008450  0.0017958  -0.471  0.639481
## code8      -0.0035003  0.0014285  -2.450  0.016853 *
## code9      -0.0008972  0.0014285  -0.628  0.532090
## code10     0.0006126  0.0013676   0.448  0.655642
## code11     -0.0013563  0.0014290  -0.949  0.345935
## code12     -0.0026214  0.0014290  -1.834  0.070964 .
## code13     -0.0011927  0.0013676  -0.872  0.386219
## code14     -0.0015170  0.0013676  -1.109  0.271241
## code15     -0.0036461  0.0015083  -2.417  0.018318 *
## year2015   -0.0048901  0.0009671  -5.057  3.45e-06 ***
## year2016    0.0019349  0.0009542   2.028  0.046498 *
## year2017    0.0015929  0.0010024   1.589  0.116659
## year2018    0.0013497  0.0010560   1.278  0.205539
## year2019    0.0014141  0.0010903   1.297  0.199025
## year2020    0.0028448  0.0010281   2.767  0.007279 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.002559 on 68 degrees of freedom
## (16 observations deleted due to missingness)
## Multiple R-squared:  0.6356, Adjusted R-squared:  0.5284
## F-statistic: 5.931 on 20 and 68 DF, p-value: 1.382e-08

#точка как случайный эффект
modTBLogtimeMaxMM <- lmer(TBLogMax ~ year + (1|code), PMdata, na.action=na.omit)
anova(modTBLogtimeMaxMM)

## Analysis of Variance Table
##      npar      Sum Sq    Mean Sq F value
## year      6 0.00051647  8.6078e-05  13.286

summary(modTBLogtimeMaxMM)

## Linear mixed model fit by REML ['lmerMod']
## Formula: TBLogMax ~ year + (1 | code)
##      Data: PMdata
##
## REML criterion at convergence: -715.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.2140 -0.5673 -0.0350  0.5580  3.1957
##
## Random effects:
##      Groups      Name              Variance Std.Dev.
##      code      (Intercept) 1.965e-06 0.001402
##      Residual              6.479e-06 0.002545
## Number of obs: 89, groups: code, 15
##
## Fixed effects:

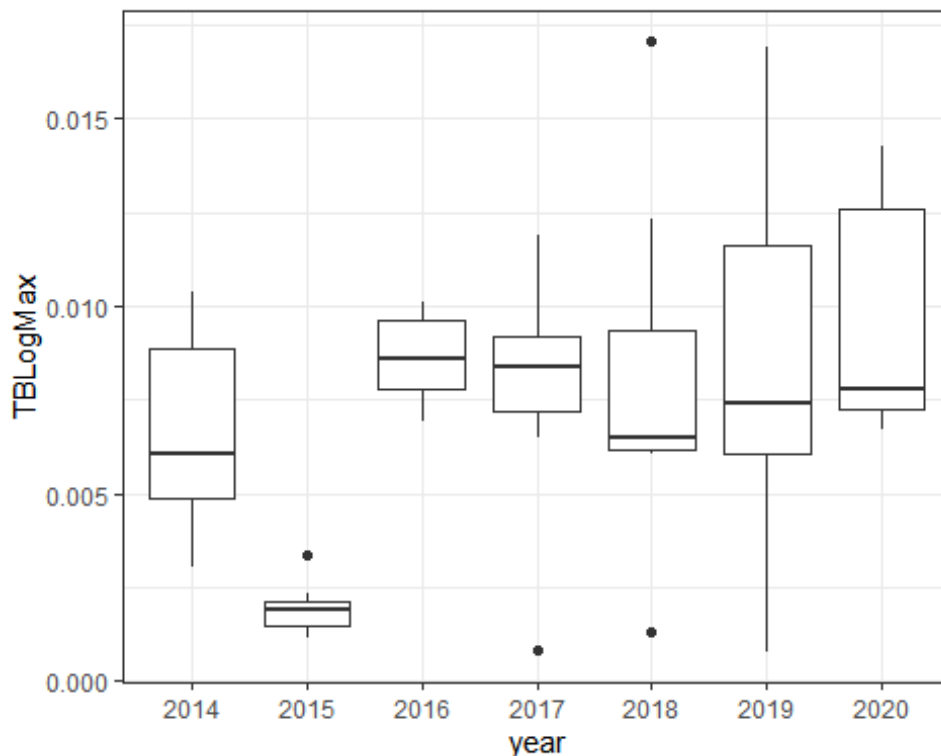
```



```
##           Estimate Std. Error t value
## (Intercept) 0.0067163 0.0007730 8.688
## year2015    -0.0048901 0.0009621 -5.083
## year2016     0.0018929 0.0009479 1.997
## year2017     0.0015134 0.0009886 1.531
## year2018     0.0012630 0.0010391 1.216
## year2019     0.0013404 0.0010709 1.252
## year2020     0.0027888 0.0010124 2.755
##
## Correlation of Fixed Effects:
##           (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015 -0.622
## year2016 -0.637 0.507
## year2017 -0.612 0.487 0.499
## year2018 -0.583 0.463 0.476 0.467
## year2019 -0.566 0.449 0.462 0.454 0.430
## year2020 -0.598 0.475 0.488 0.479 0.456 0.448

ggplot(PMdata, aes(x = year, y = TBLogMax)) + geom_boxplot()

## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



```
modTBLogtimenullMaxMM <- lmer(TBLogMax ~ (1|code), PMdata)
anova(modTBLogtimenullMaxMM, modTBLogtimeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modTBLogtimenullMaxMM: TBLogMax ~ (1 | code)
```

```
## modTBlogtimeMaxMM: TBlogMax ~ year + (1 | code)
##               npar      AIC      BIC logLik deviance  Chisq Df Pr(>Chis
q)
## modTBlogtimenullMaxMM      3 -738.96 -731.49 372.48  -744.96
## modTBlogtimeMaxMM          9 -784.74 -762.34 401.37  -802.74 57.783  6  1.268e-
10
##
## modTBlogtimenullMaxMM
## modTBlogtimeMaxMM      ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#PLogMax - увеличивается во времени
modPLogtimeMax <- lm(PLogMax ~ code + year, PMdata)
anova(modPLogtimeMax)

## Analysis of Variance Table
##
## Response: PLogMax
##           Df      Sum Sq    Mean Sq F value    Pr(>F)
## code       14 0.00057273 0.00004091  3.5918 0.0001945 ***
## year        6 0.00087477 0.00014579 12.8006 1.286e-09 ***
## Residuals  68 0.00077450 0.00001139
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(modPLogtimeMax)

##
## Call:
## lm(formula = PLogMax ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.0064797 -0.0021654 -0.0000077  0.0022577  0.0083131
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.011454   0.001538   7.450 2.19e-10 ***
## code2        -0.004301   0.002369  -1.816  0.07382 .
## code3        -0.004655   0.001991  -2.337  0.02237 *
## code4        -0.007757   0.001804  -4.300 5.59e-05 ***
## code5        -0.007854   0.001804  -4.354 4.62e-05 ***
## code6        -0.003387   0.001804  -1.878  0.06472 .
## code7        -0.001066   0.002369  -0.450  0.65419
## code8        -0.005017   0.001884  -2.663  0.00967 **
## code9        -0.001135   0.001884  -0.603  0.54884
## code10        0.000290   0.001804   0.161  0.87276
## code11       -0.001857   0.001885  -0.985  0.32810
## code12       -0.003567   0.001885  -1.893  0.06268 .
## code13       -0.002125   0.001804  -1.178  0.24294
## code14       -0.002123   0.001804  -1.177  0.24341
## code15       -0.005008   0.001989  -2.517  0.01419 *
```

```

## year2015    -0.005896    0.001276   -4.622  1.75e-05 ***
## year2016     0.003294    0.001259    2.617   0.01092 *
## year2017     0.002917    0.001322    2.207   0.03073 *
## year2018     0.002224    0.001393    1.597   0.11495
## year2019     0.001938    0.001438    1.347   0.18236
## year2020     0.003623    0.001356    2.672   0.00944 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.003375 on 68 degrees of freedom
## (16 observations deleted due to missingness)
## Multiple R-squared:  0.6514, Adjusted R-squared:  0.5489
## F-statistic: 6.354 on 20 and 68 DF,  p-value: 3.77e-09

#точка как случайный эффект
modPLogtimeMaxMM <- lmer(PLogMax ~ year + (1|code), PMdata, na.action=na.omit)
anova(modPLogtimeMaxMM)

## Analysis of Variance Table
##      npar      Sum Sq   Mean Sq F value
## year      6 0.00087631 0.00014605  12.927

summary(modPLogtimeMaxMM)

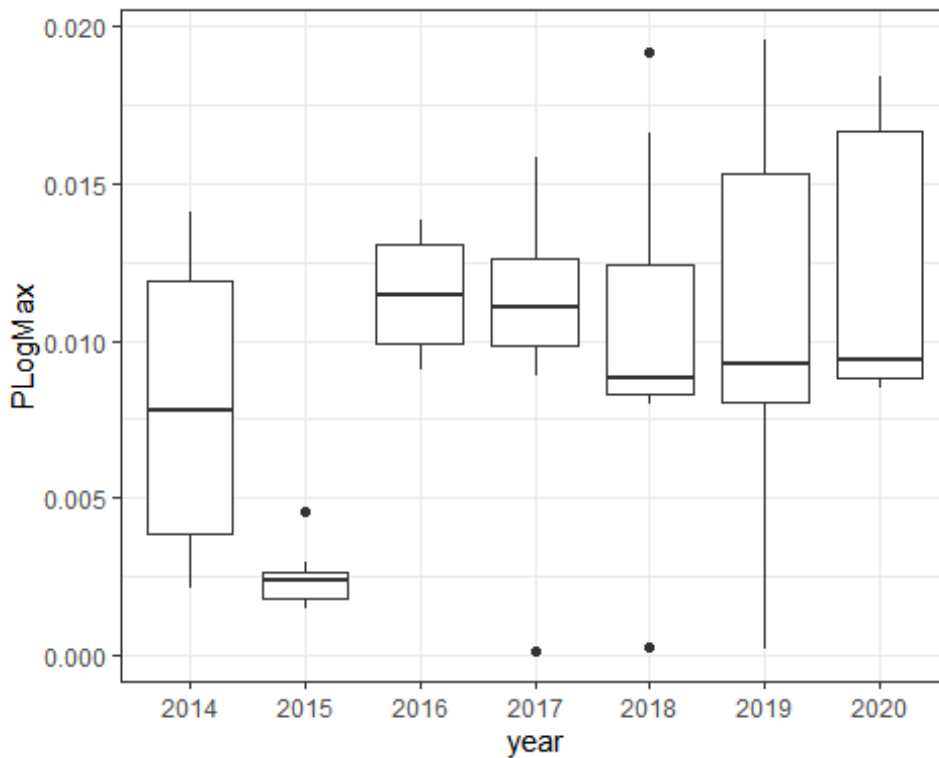
## Linear mixed model fit by REML ['lmerMod']
## Formula: PLogMax ~ year + (1 | code)
## Data: PMdata
##
## REML criterion at convergence: -666.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.25447 -0.60326  0.00127  0.63762  2.57374
##
## Random effects:
## Groups Name      Variance Std.Dev.
## code   (Intercept) 4.724e-06 0.002174
## Residual              1.130e-05 0.003361
## Number of obs: 89, groups: code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.008191   0.001063   7.708
## year2015    -0.005896   0.001270  -4.641
## year2016     0.003253   0.001252   2.598
## year2017     0.002832   0.001307   2.166
## year2018     0.002119   0.001375   1.541
## year2019     0.001850   0.001417   1.305
## year2020     0.003570   0.001339   2.666
##
## Correlation of Fixed Effects:
##              (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015    -0.598

```

```
## year2016 -0.612  0.507
## year2017 -0.588  0.486  0.499
## year2018 -0.560  0.462  0.475  0.468
## year2019 -0.544  0.448  0.462  0.455  0.430
## year2020 -0.574  0.474  0.487  0.480  0.457  0.450

ggplot(PMdata, aes(x = year, y = PLogMax)) + geom_boxplot()

## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



```
modPLogtimenullMaxMM <- lmer(PLogMax ~ (1|code), PMdata)
anova(modPLogtimenullMaxMM, modPLogtimeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modPLogtimenullMaxMM: PLogMax ~ (1 | code)
## modPLogtimeMaxMM: PLogMax ~ year + (1 | code)
##          npar      AIC      BIC logLik deviance Chisq Df Pr(>Chisq)
## modPLogtimenullMaxMM      3 -687.42 -679.96 346.71  -693.42
## modPLogtimeMaxMM          9 -732.03 -709.63 375.01  -750.03 56.604  6 2.197e-10
##
## modPLogtimenullMaxMM
## modPLogtimeMaxMM      ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

#TBPLogMax - увеличивается во времени

```
modTBPLogtimeMax <- lm(TBPLogMax ~ code + year, PMdata)
anova(modTBPLogtimeMax)
```

```
## Analysis of Variance Table
```

```
##
```

```
## Response: TBPLogMax
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
## code	14	0.0016020	0.00011443	3.3114	0.0004713	***
## year	6	0.0027243	0.00045404	13.1388	8.2e-10	***
## Residuals	68	0.0023499	0.00003456			

```
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(modTBPLogtimeMax)
```

```
##
```

```
## Call:
```

```
## lm(formula = TBPLogMax ~ code + year, data = PMdata)
```

```
##
```

```
## Residuals:
```

	Min	1Q	Median	3Q	Max
##	-0.0113113	-0.0040548	0.0002434	0.0036333	0.0160962

```
##
```

```
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t)	
## (Intercept)	0.0203320	0.0026782	7.592	1.21e-10	***
## code2	-0.0069820	0.0041260	-1.692	0.095189	.
## code3	-0.0076649	0.0034687	-2.210	0.030492	*
## code4	-0.0125747	0.0031422	-4.002	0.000158	***
## code5	-0.0131243	0.0031422	-4.177	8.62e-05	***
## code6	-0.0056906	0.0031422	-1.811	0.074556	.
## code7	-0.0019104	0.0041260	-0.463	0.644842	
## code8	-0.0085173	0.0032822	-2.595	0.011577	*
## code9	-0.0020326	0.0032822	-0.619	0.537795	
## code10	0.0009027	0.0031422	0.287	0.774767	
## code11	-0.0032130	0.0032832	-0.979	0.331247	
## code12	-0.0061883	0.0032832	-1.885	0.063729	.
## code13	-0.0033174	0.0031422	-1.056	0.294813	
## code14	-0.0036397	0.0031422	-1.158	0.250781	
## code15	-0.0086540	0.0034653	-2.497	0.014940	*
## year2015	-0.0107868	0.0022219	-4.855	7.38e-06	***
## year2016	0.0052280	0.0021923	2.385	0.019887	*
## year2017	0.0045100	0.0023030	1.958	0.054294	.
## year2018	0.0035734	0.0024261	1.473	0.145393	
## year2019	0.0033512	0.0025050	1.338	0.185416	
## year2020	0.0064674	0.0023621	2.738	0.007883	**

```
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
```

```
## Residual standard error: 0.005879 on 68 degrees of freedom
```

```
## (16 observations deleted due to missingness)
```

```
## Multiple R-squared:  0.648, Adjusted R-squared:  0.5445
## F-statistic:  6.26 on 20 and 68 DF,  p-value: 5.024e-09

#точка как случайный эффект
modTBPLogtimeMaxMM <- lmer(TBPLogMax ~ year + (1|code), PMdata, na.action=na.omit)
anova(modTBPLogtimeMaxMM)

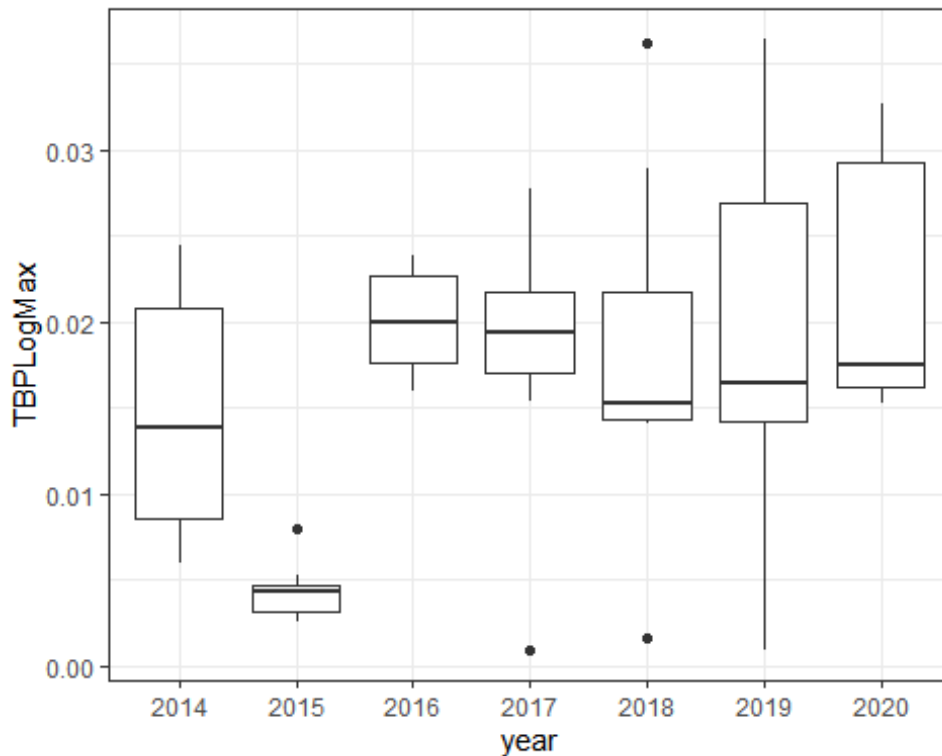
## Analysis of Variance Table
##      npar  Sum Sq    Mean Sq F value
## year      6 0.00273 0.00045501  13.284

summary(modTBPLogtimeMaxMM)

## Linear mixed model fit by REML ['lmerMod']
## Formula: TBPLogMax ~ year + (1 | code)
##      Data: PMdata
##
## REML criterion at convergence: -576.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.25469 -0.60834 -0.02797  0.59095  2.86473
##
## Random effects:
##      Groups      Name      Variance Std.Dev.
##      code      (Intercept) 1.282e-05 0.003581
##      Residual              3.425e-05 0.005853
## Number of obs: 89, groups:  code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.014906   0.001823   8.177
## year2015     -0.010787   0.002212  -4.876
## year2016      0.005147   0.002180   2.361
## year2017      0.004348   0.002275   1.911
## year2018      0.003384   0.002392   1.415
## year2019      0.003192   0.002466   1.294
## year2020      0.006361   0.002330   2.730
##
## Correlation of Fixed Effects:
##              (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015    -0.607
## year2016    -0.621  0.507
## year2017    -0.596  0.486  0.499
## year2018    -0.568  0.462  0.475  0.468
## year2019    -0.552  0.449  0.462  0.455  0.430
## year2020    -0.583  0.475  0.488  0.480  0.456  0.449

ggplot(PMdata, aes(x = year, y = TBPLogMax)) + geom_boxplot()

## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



```
modTBPLogtimenullMaxMM <- lmer(TBPLogMax ~ (1|code), PMdata)
anova(modTBPLogtimenullMaxMM, modTBPLogtimeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modTBPLogtimenullMaxMM: TBPLogMax ~ (1 | code)
## modTBPLogtimeMaxMM: TBPLogMax ~ year + (1 | code)
##
```

	npair	AIC	BIC	logLik	deviance	Chisq	Df
modTBPLogtimenullMaxMM	3	-588.74	-581.27	297.37	-594.74		
modTBPLogtimeMaxMM	9	-634.46	-612.07	326.23	-652.46	57.727	6

```
## Pr(>Chisq)
## modTBPLogtimenullMaxMM
## modTBPLogtimeMaxMM      1.302e-10 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#TotalMax - увеличивается во времени!!!
modTotalLogtimeMax <- lm(TotalLogMax ~ code + year, PMdata)
anova(modTotalLogtimeMax)

## Analysis of Variance Table
##
## Response: TotalLogMax
##
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
code	14	0.059078	0.0042199	3.1225	0.0008597 ***
year	6	0.134266	0.0223777	16.5584	1.163e-11 ***
Residuals	68	0.091898	0.0013514		

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

summary(modTotalLogtimeMax)

##
## Call:
## lm(formula = TotalLogMax ~ code + year, data = PMdata)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.064023 -0.025378 -0.001277  0.022594  0.073685
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.139574   0.016748   8.334 5.43e-12 ***
## code2        -0.052906   0.025803  -2.050 0.044184 *
## code3        -0.058216   0.021692  -2.684 0.009133 **
## code4        -0.079237   0.019650  -4.032 0.000142 ***
## code5        -0.066127   0.019650  -3.365 0.001261 **
## code6        -0.047636   0.019650  -2.424 0.018005 *
## code7        -0.011334   0.025803  -0.439 0.661862
## code8        -0.064827   0.020525  -3.158 0.002367 **
## code9        -0.011556   0.020525  -0.563 0.575283
## code10       -0.003405   0.019650  -0.173 0.862962
## code11       -0.006191   0.020532  -0.302 0.763938
## code12       -0.037822   0.020532  -1.842 0.069820 .
## code13       -0.035212   0.019650  -1.792 0.077588 .
## code14       -0.029731   0.019650  -1.513 0.134907
## code15       -0.059359   0.021671  -2.739 0.007859 **
## year2015     -0.079531   0.013895  -5.724 2.57e-07 ***
## year2016      0.031791   0.013710   2.319 0.023417 *
## year2017      0.039887   0.014402   2.770 0.007230 **
## year2018      0.032238   0.015172   2.125 0.037238 *
## year2019      0.021347   0.015665   1.363 0.177483
## year2020      0.021170   0.014772   1.433 0.156394
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.03676 on 68 degrees of freedom
## (16 observations deleted due to missingness)
## Multiple R-squared:  0.6778, Adjusted R-squared:  0.5831
## F-statistic: 7.153 on 20 and 68 DF,  p-value: 3.647e-10

#точка как случайный эффект
modTotalLogtimeMaxMM <- lmer(TotalLogMax ~ year + (1|code), PMdata, na.action=na
.omit)
anova(modTotalLogtimeMaxMM)

## Analysis of Variance Table
##      npar  Sum Sq Mean Sq F value
## year      6 0.13459  0.022432  16.691

```



```

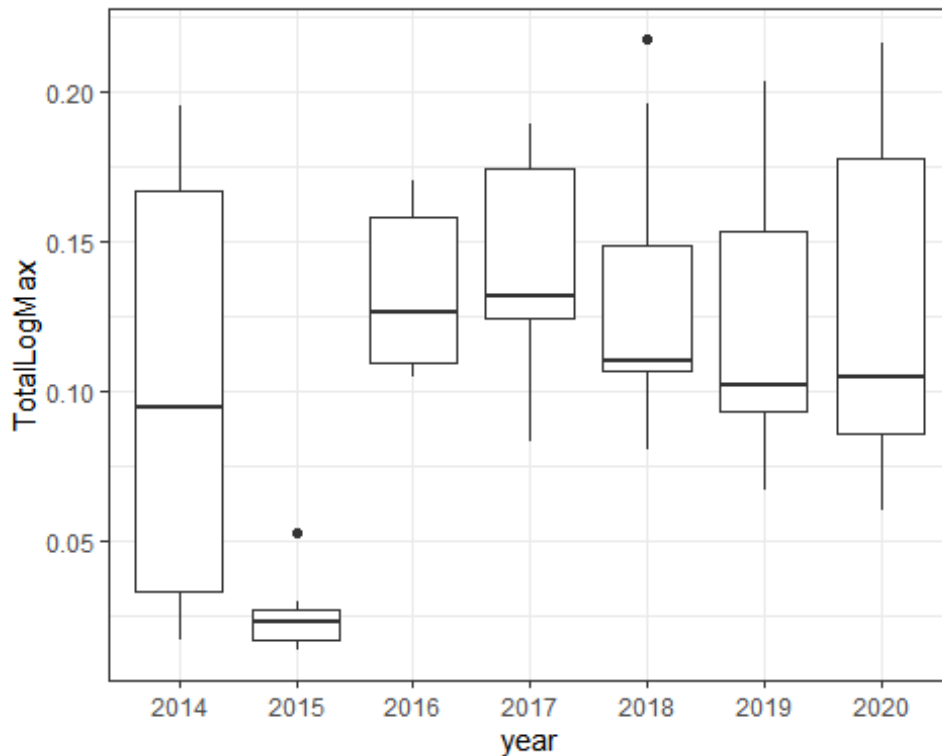
summary(modTotalLogtimeMaxMM)

## Linear mixed model fit by REML ['lmerMod']
## Formula: TotalLogMax ~ year + (1 | code)
## Data: PMdata
##
## REML criterion at convergence: -276.3
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.96545 -0.68301 -0.01334  0.57804  2.04316
##
## Random effects:
## Groups Name Variance Std.Dev.
## code (Intercept) 0.0004729 0.02175
## Residual 0.0013440 0.03666
## Number of obs: 89, groups: code, 15
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.10258    0.01133   9.055
## year2015     -0.07953    0.01386  -5.740
## year2016      0.03121    0.01365   2.286
## year2017      0.03887    0.01425   2.728
## year2018      0.03118    0.01498   2.081
## year2019      0.01993    0.01544   1.291
## year2020      0.02074    0.01459   1.421
##
## Correlation of Fixed Effects:
##              (Intr) yr2015 yr2016 yr2017 yr2018 yr2019
## year2015 -0.612
## year2016 -0.626  0.507
## year2017 -0.601  0.486  0.499
## year2018 -0.573  0.463  0.475  0.468
## year2019 -0.557  0.449  0.462  0.454  0.430
## year2020 -0.588  0.475  0.488  0.480  0.456  0.449

ggplot(PMdata, aes(x = year, y = TotalLogMax)) + geom_boxplot()

## Warning: Removed 16 rows containing non-finite values (stat_boxplot).

```



```
modTotalLogtimenullMaxMM <- lmer(TotalLogMax ~ (1|code), PMdata)
anova(modTotalLogtimenullMaxMM, modTotalLogtimeMaxMM)

## refitting model(s) with ML (instead of REML)

## Data: PMdata
## Models:
## modTotalLogtimenullMaxMM: TotalLogMax ~ (1 | code)
## modTotalLogtimeMaxMM: TotalLogMax ~ year + (1 | code)
##
```

	npar	AIC	BIC	loglik	deviance	Chisq	Df
## modTotalLogtimenullMaxMM	3	-253.22	-245.75	129.61	-259.22		
## modTotalLogtimeMaxMM	9	-308.49	-286.10	163.25	-326.49	67.274	6

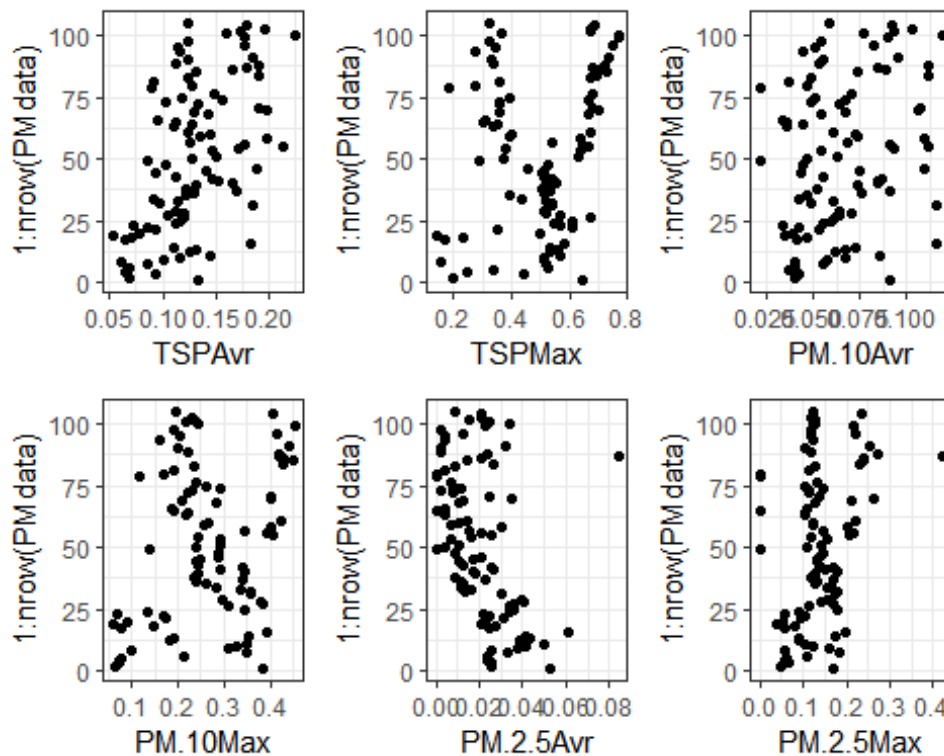
```
## Pr(>Chisq)
## modTotalLogtimenullMaxMM
## modTotalLogtimeMaxMM 1.479e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

#Нет ли выбросов? Строим диаграммы Кливленда
gg_dot <- ggplot(PMdata, aes(y = 1:nrow(PMdata))) + geom_point()

plot_grid(gg_dot + aes(x = TSPAвр),
          gg_dot + aes(x = TSPMax),
          gg_dot + aes(x = PM.10Авр),
          gg_dot + aes(x = PM.10Max),
          gg_dot + aes(x = PM.2.5Авр),
          gg_dot + aes(x = PM.2.5Max))

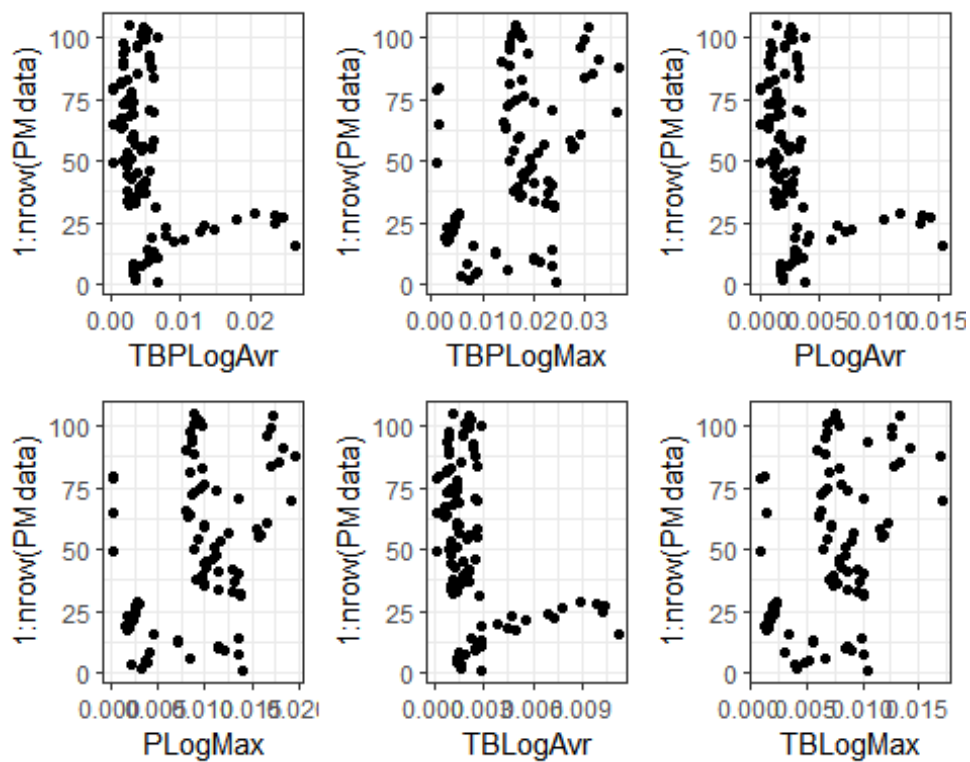
## Warning: Removed 12 rows containing missing values (geom_point).
```

```
## Warning: Removed 12 rows containing missing values (geom_point).
## Warning: Removed 12 rows containing missing values (geom_point).
## Warning: Removed 12 rows containing missing values (geom_point).
## Warning: Removed 12 rows containing missing values (geom_point).
## Warning: Removed 12 rows containing missing values (geom_point).
```



```
plot_grid(gg_dot + aes(x = TBPLogAver),
          gg_dot + aes(x = TBPLogMax),
          gg_dot + aes(x = PLogAver),
          gg_dot + aes(x = PLogMax),
          gg_dot + aes(x = TBLogAver),
          gg_dot + aes(x = TBLogMax))
```

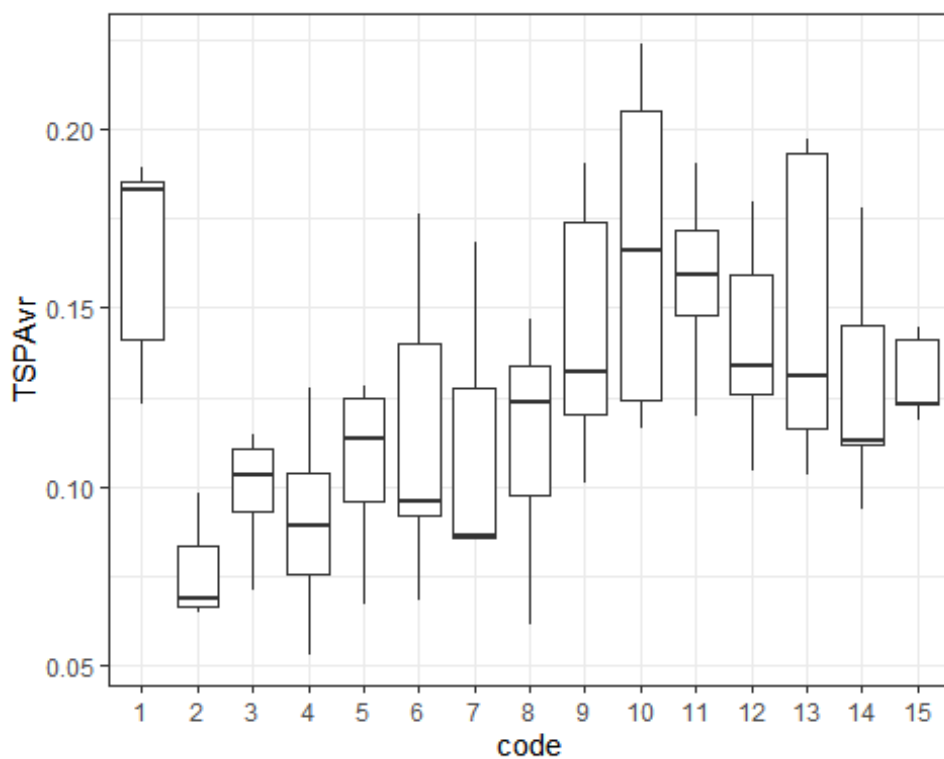
```
## Warning: Removed 7 rows containing missing values (geom_point).
## Warning: Removed 16 rows containing missing values (geom_point).
## Warning: Removed 7 rows containing missing values (geom_point).
## Warning: Removed 16 rows containing missing values (geom_point).
## Warning: Removed 7 rows containing missing values (geom_point).
## Warning: Removed 16 rows containing missing values (geom_point).
```



#Нет ли коллинеарности дискретных и непрерывных предикторов?

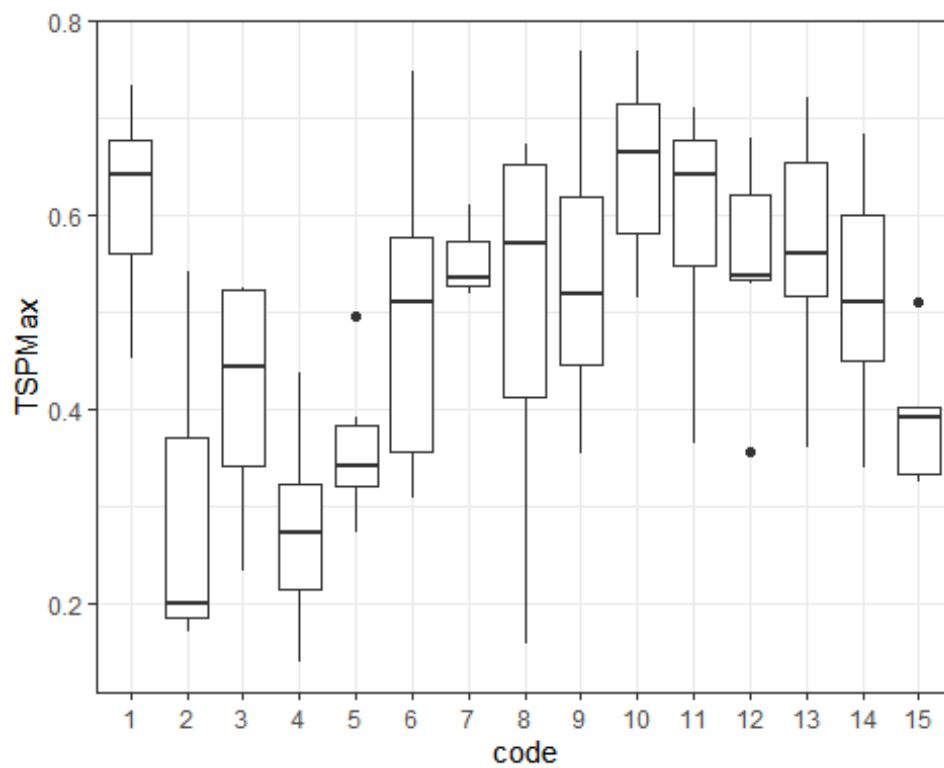
```
ggplot(PMdata, aes(x = code, y = TSPAвр)) + geom_boxplot()
```

Warning: Removed 12 rows containing non-finite values (stat_boxplot).



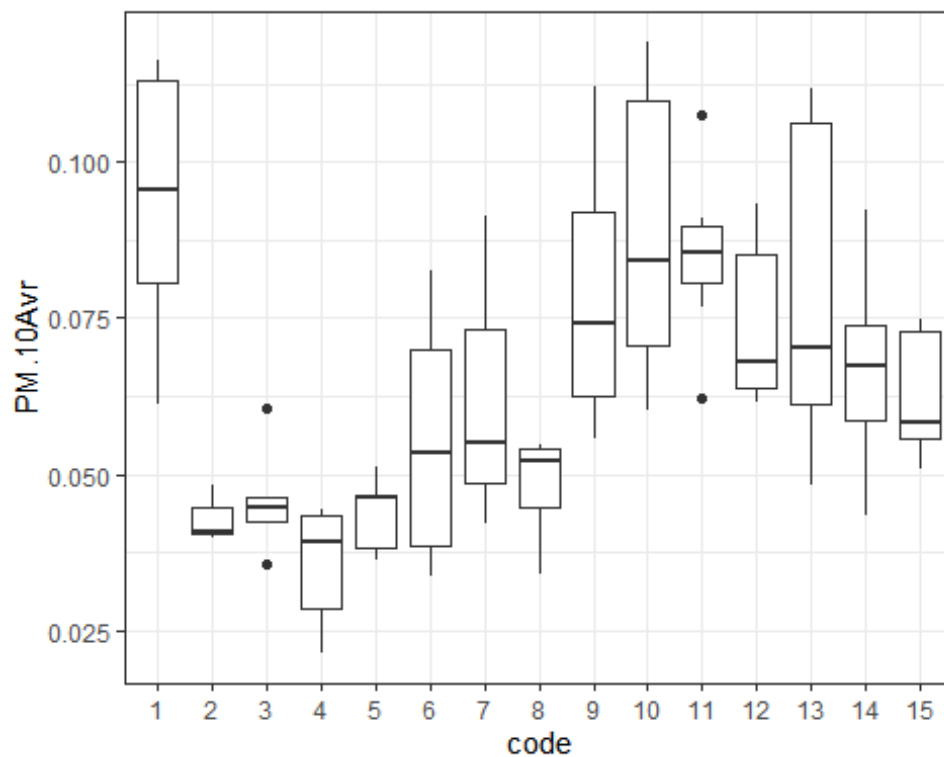
```
ggplot(PMdata, aes(x = code, y = TSPMax)) + geom_boxplot()
```

```
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

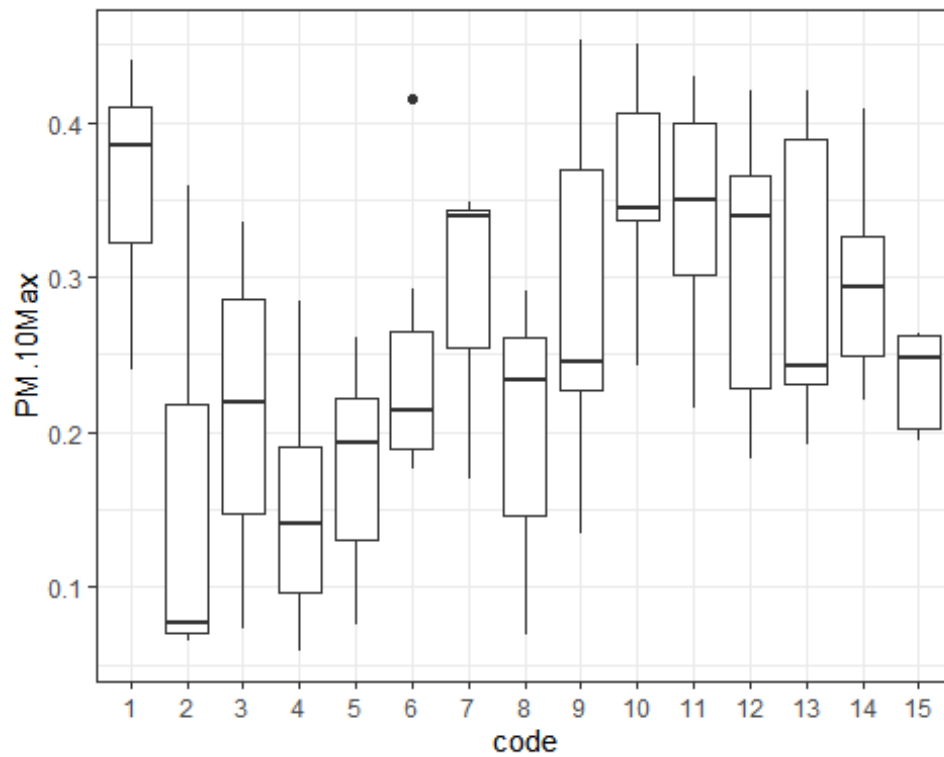


```
ggplot(PMdata, aes(x = code, y = PM.10Avr)) + geom_boxplot()
```

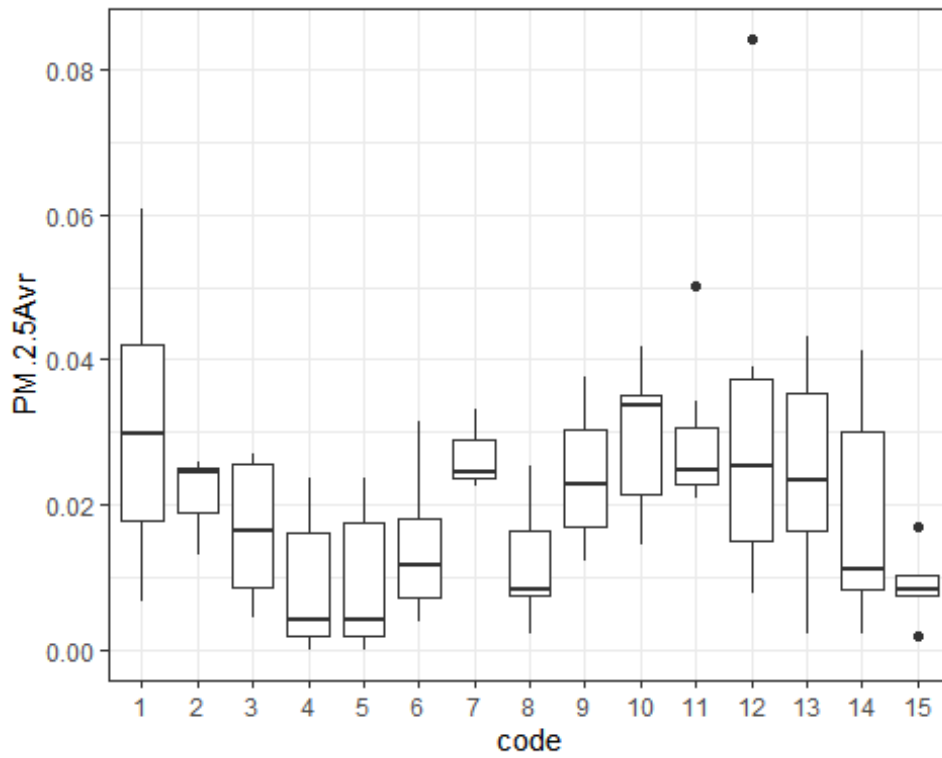
```
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



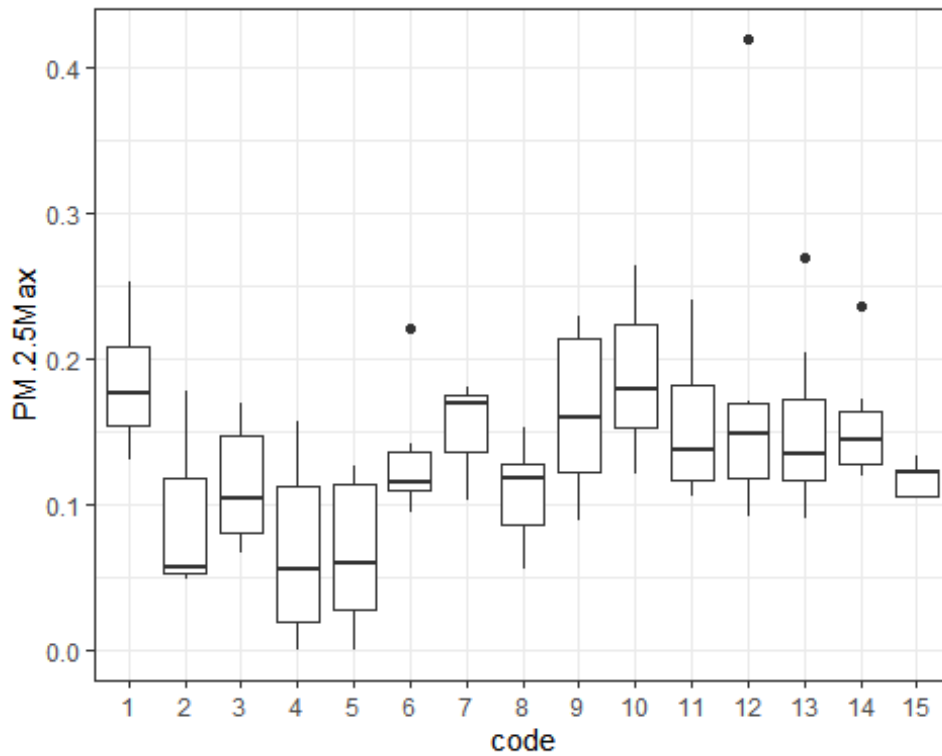
```
ggplot(PMdata, aes(x = code, y = PM.10Max)) + geom_boxplot()  
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = code, y = PM.2.5Avr)) + geom_boxplot()  
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

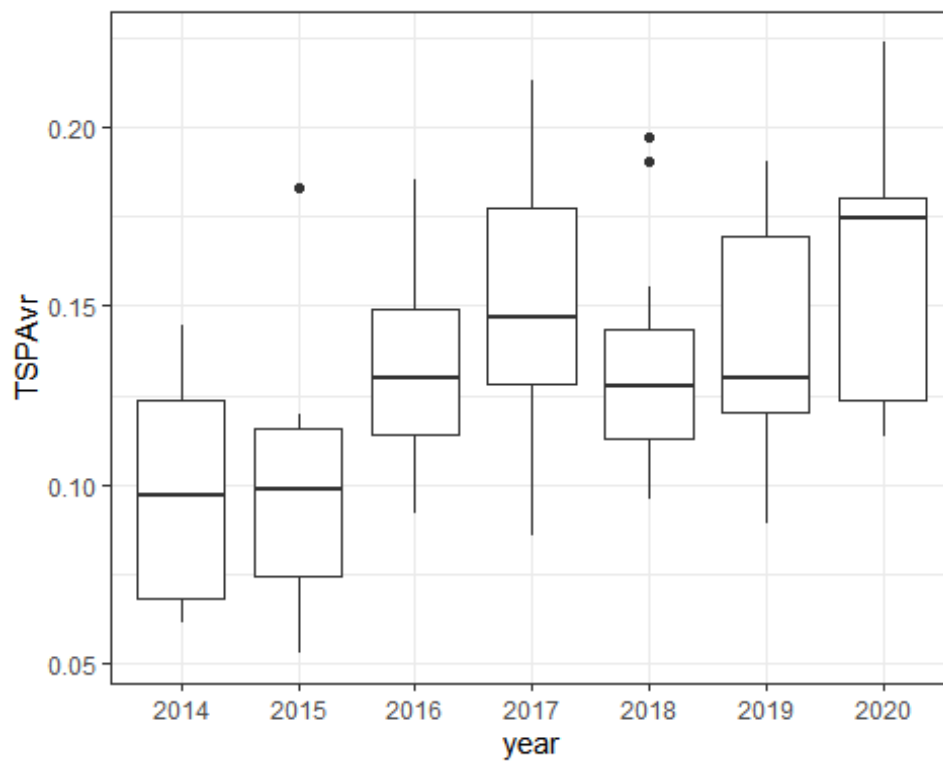


```
ggplot(PMdata, aes(x = code, y = PM.2.5Max)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



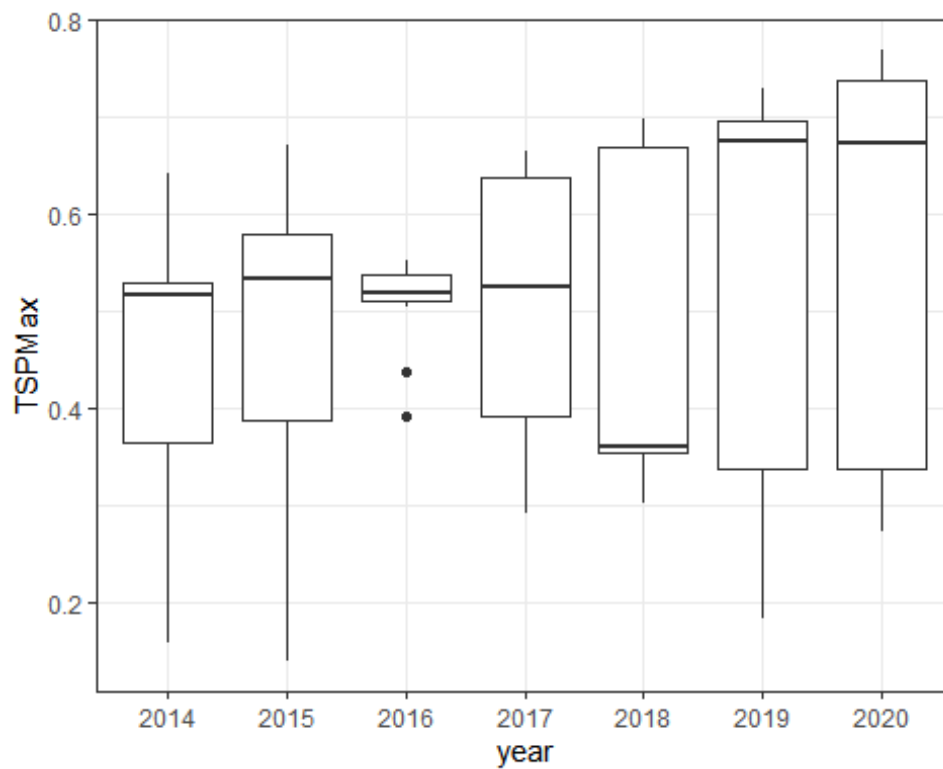
```
ggplot(PMdata, aes(x = year, y = TSPAвр)) + geom_boxplot()
```

```
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

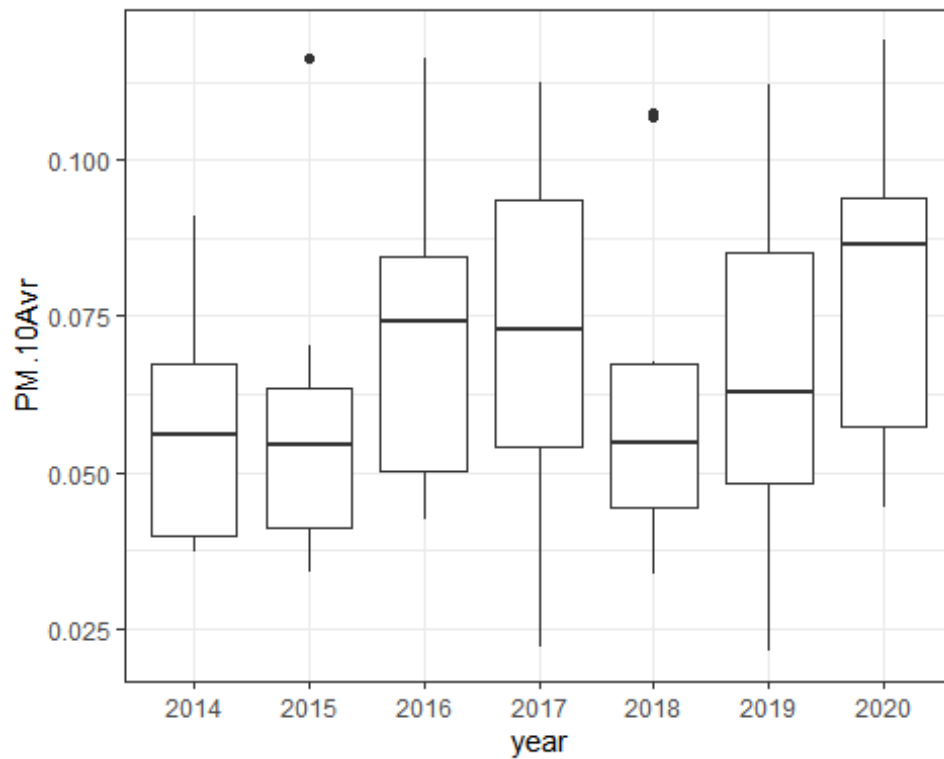


```
ggplot(PMdata, aes(x = year, y = TSPMax)) + geom_boxplot()
```

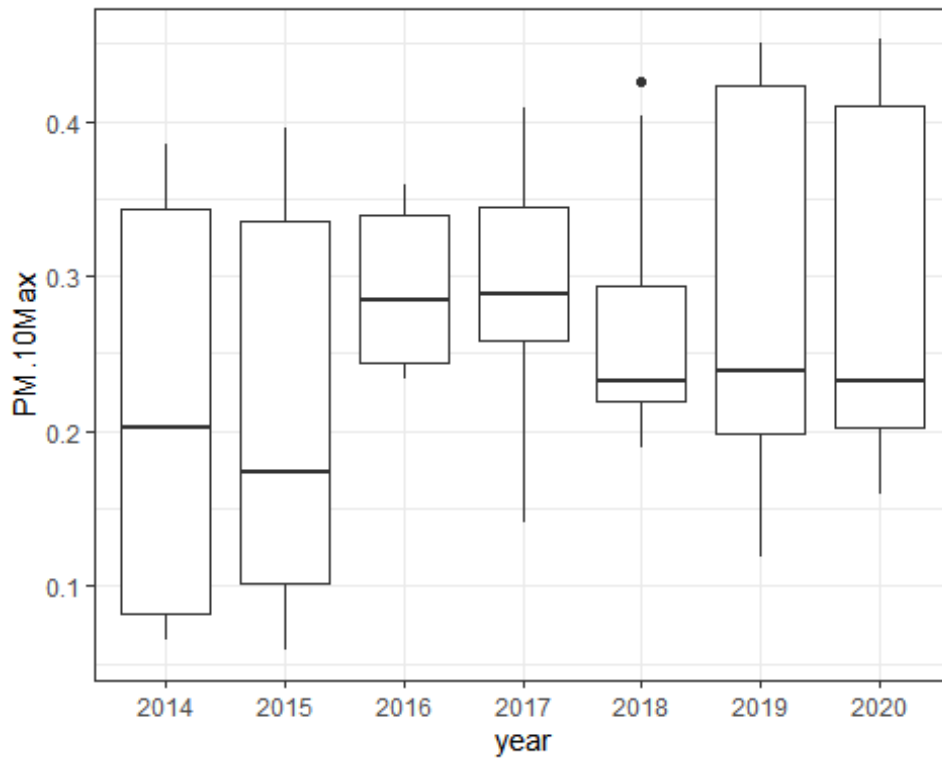
```
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



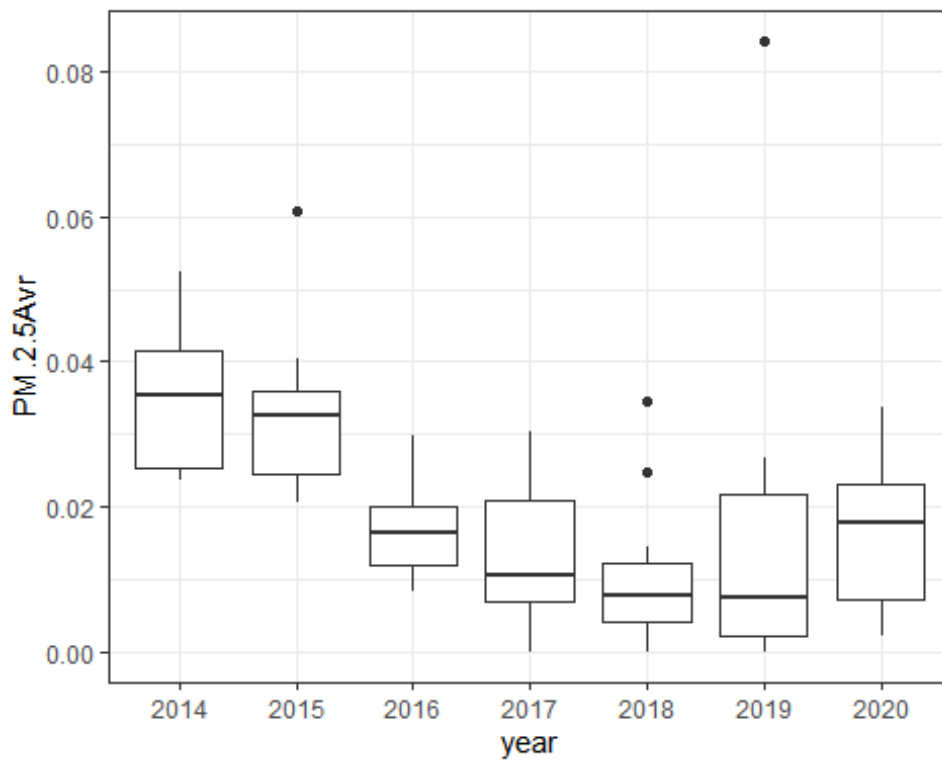

```
ggplot(PMdata, aes(x = year, y = PM.10Avr)) + geom_boxplot()  
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = year, y = PM.10Max)) + geom_boxplot()  
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

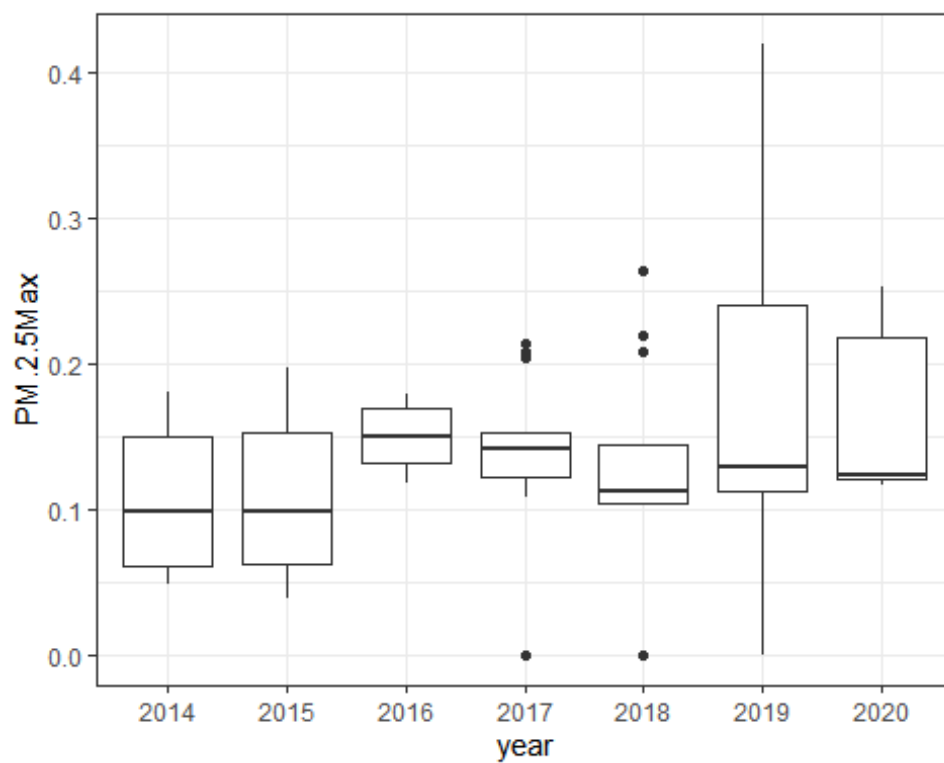


```
ggplot(PMdata, aes(x = year, y = PM.2.5Avr)) + geom_boxplot()
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```



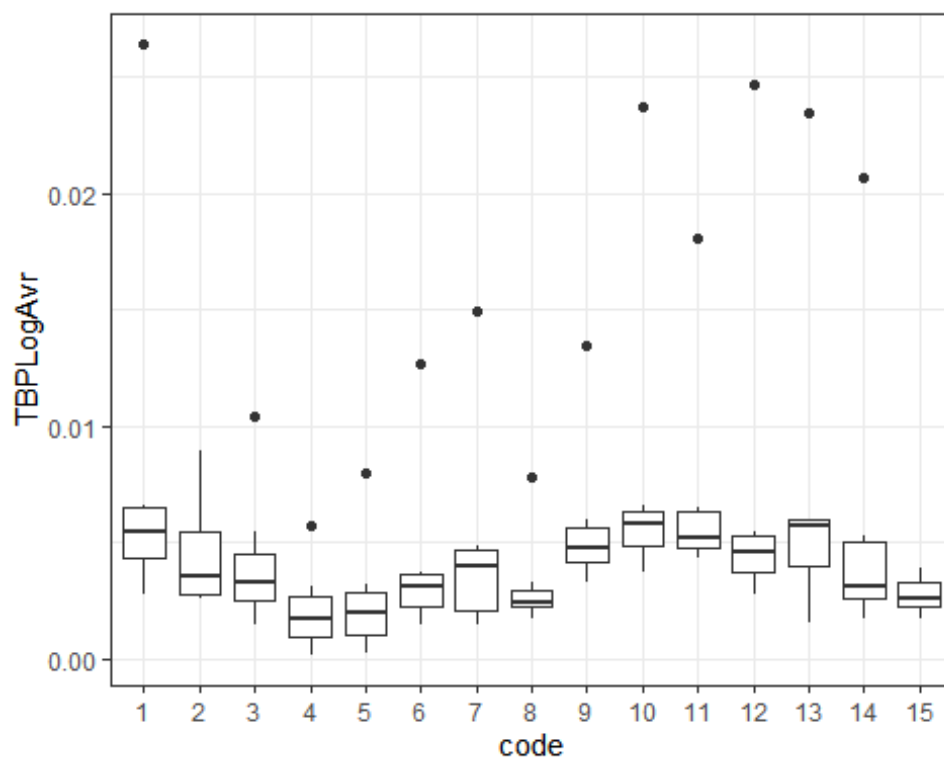
```
ggplot(PMdata, aes(x = year, y = PM.2.5Max)) + geom_boxplot()
```

```
## Warning: Removed 12 rows containing non-finite values (stat_boxplot).
```

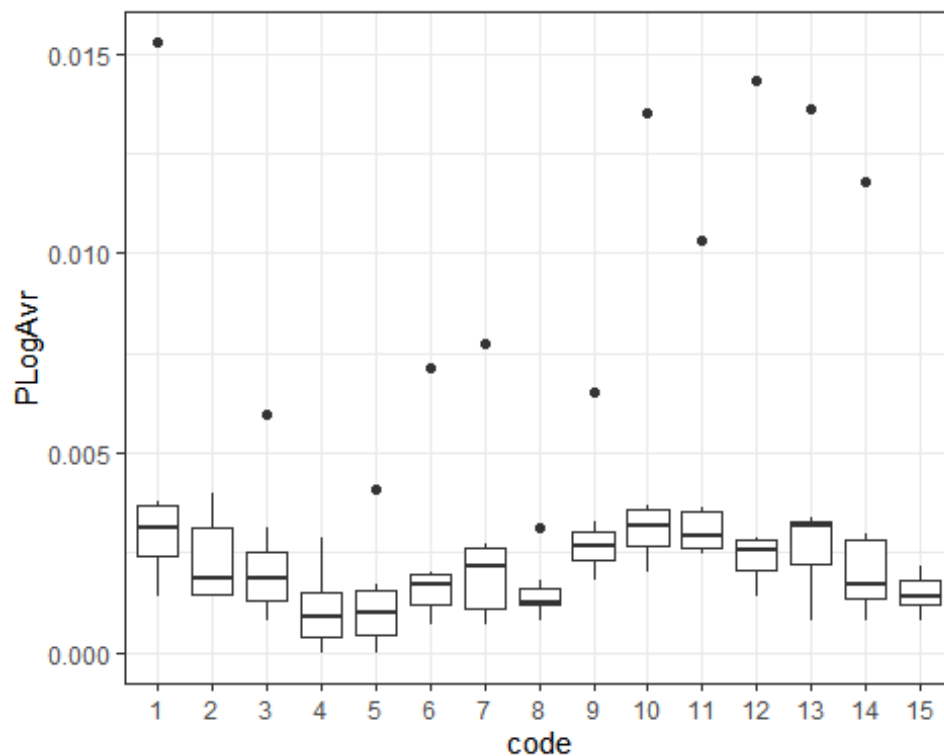


```
ggplot(PMdata, aes(x = code, y = TBPLogAvr)) + geom_boxplot()
```

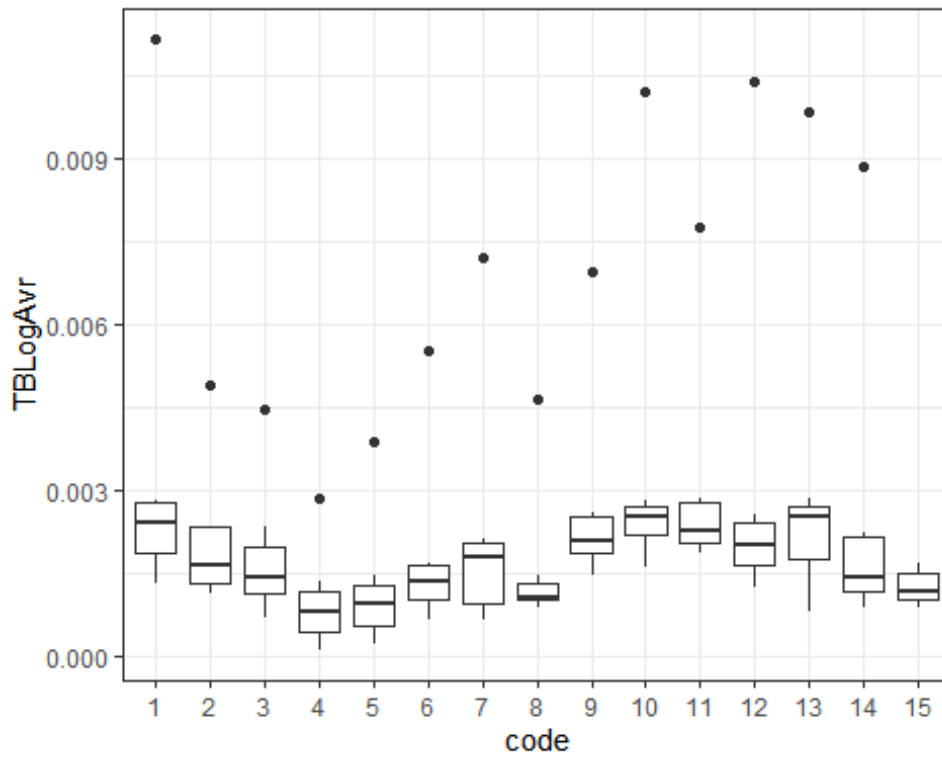
```
## Warning: Removed 7 rows containing non-finite values (stat_boxplot).
```



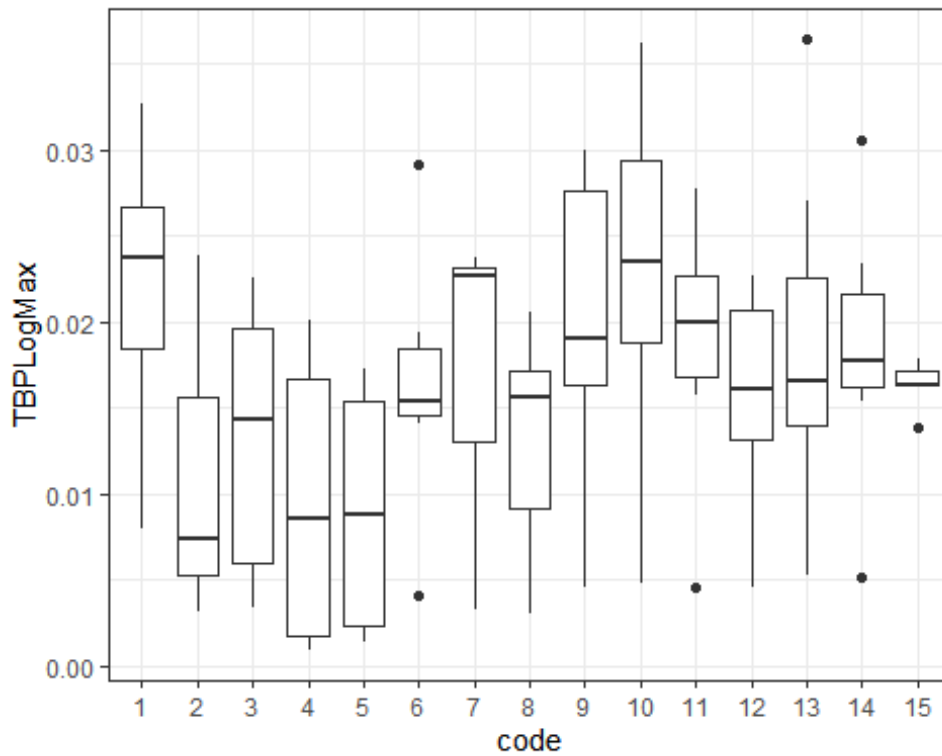
```
ggplot(PMdata, aes(x = code, y = PLogAvr)) + geom_boxplot()  
## Warning: Removed 7 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = code, y = TBLogAvr)) + geom_boxplot()  
## Warning: Removed 7 rows containing non-finite values (stat_boxplot).
```

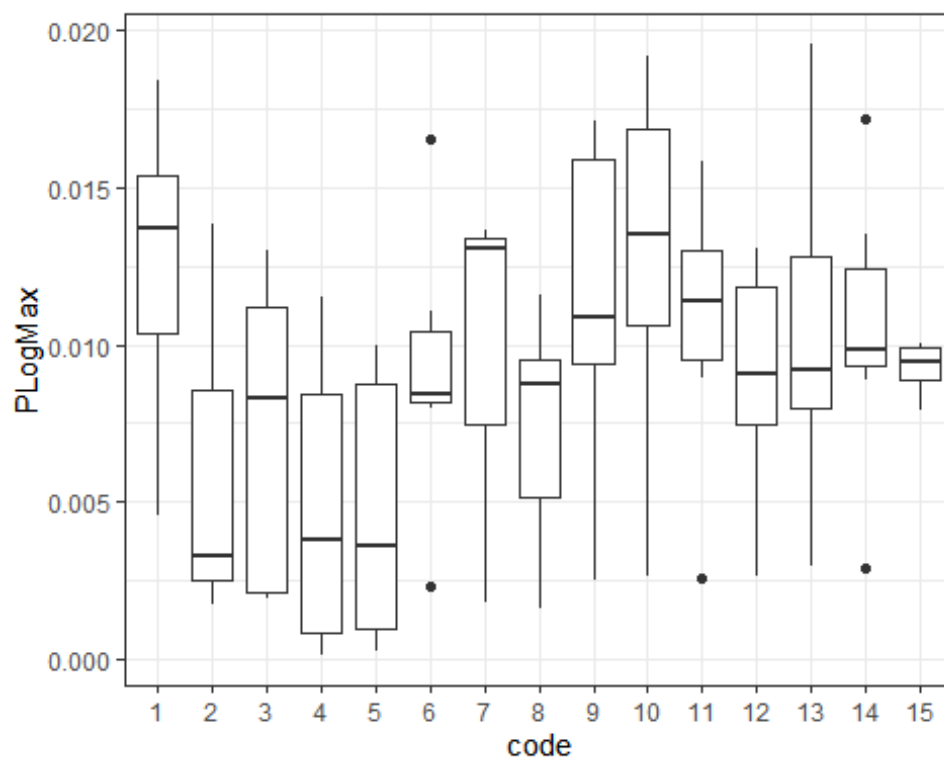


```
ggplot(PMdata, aes(x = code, y = TBPLogMax)) + geom_boxplot()
## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



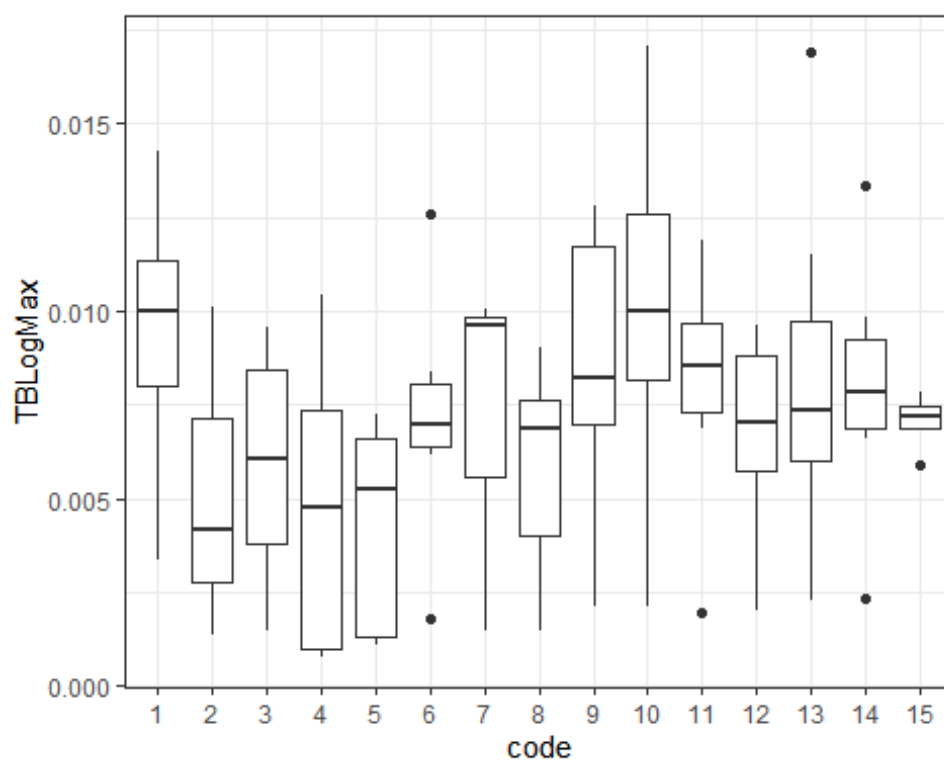
```
ggplot(PMdata, aes(x = code, y = PLogMax)) + geom_boxplot()
```

```
## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```

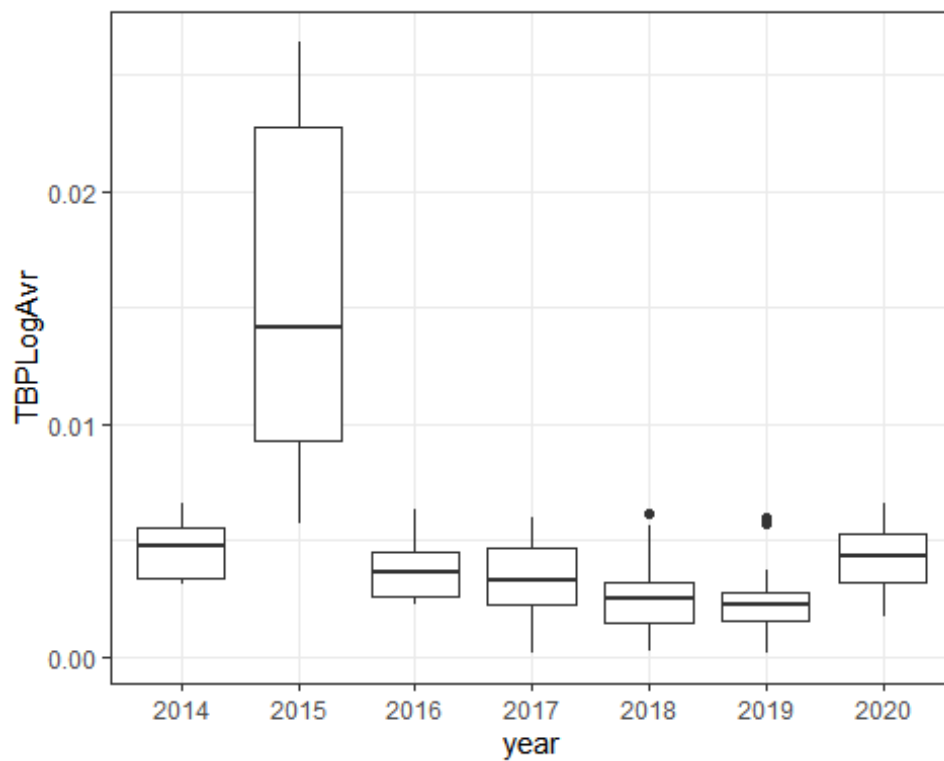


```
ggplot(PMdata, aes(x = code, y = TBLogMax)) + geom_boxplot()
```

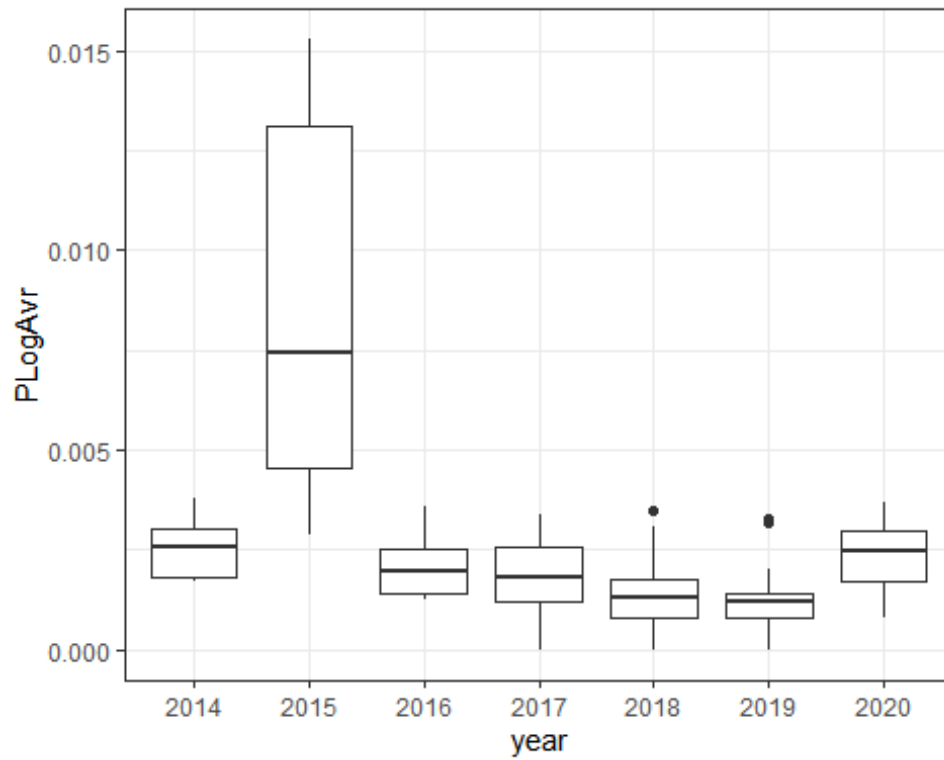
```
## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



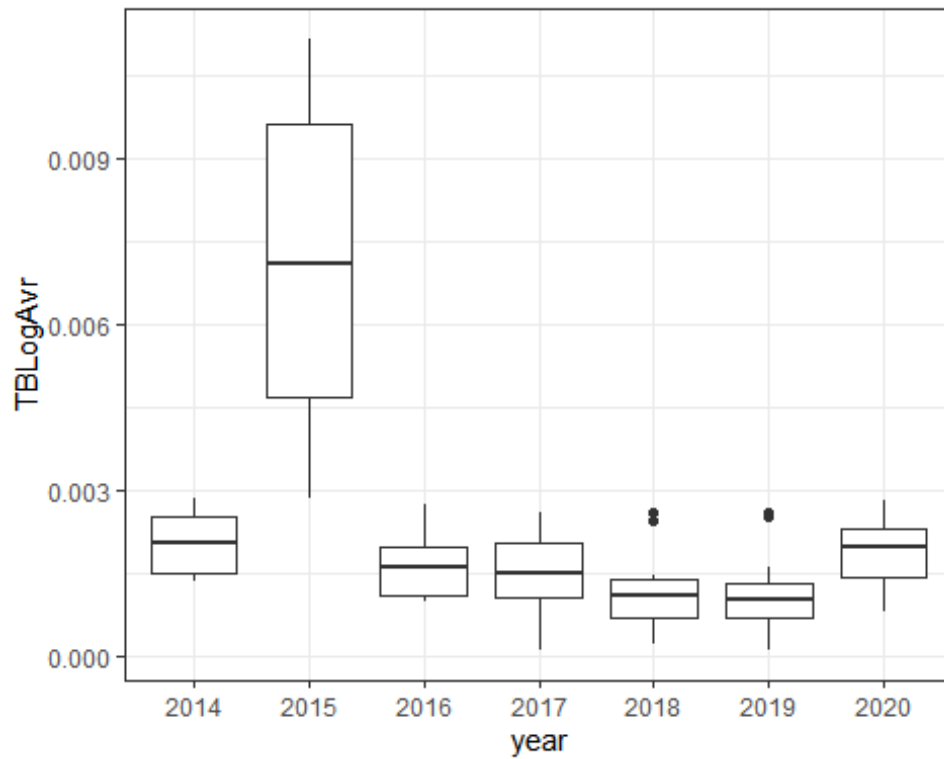
```
ggplot(PMdata, aes(x = year, y = TBPLogAvr)) + geom_boxplot()  
## Warning: Removed 7 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = year, y = PLogAvr)) + geom_boxplot()  
## Warning: Removed 7 rows containing non-finite values (stat_boxplot).
```



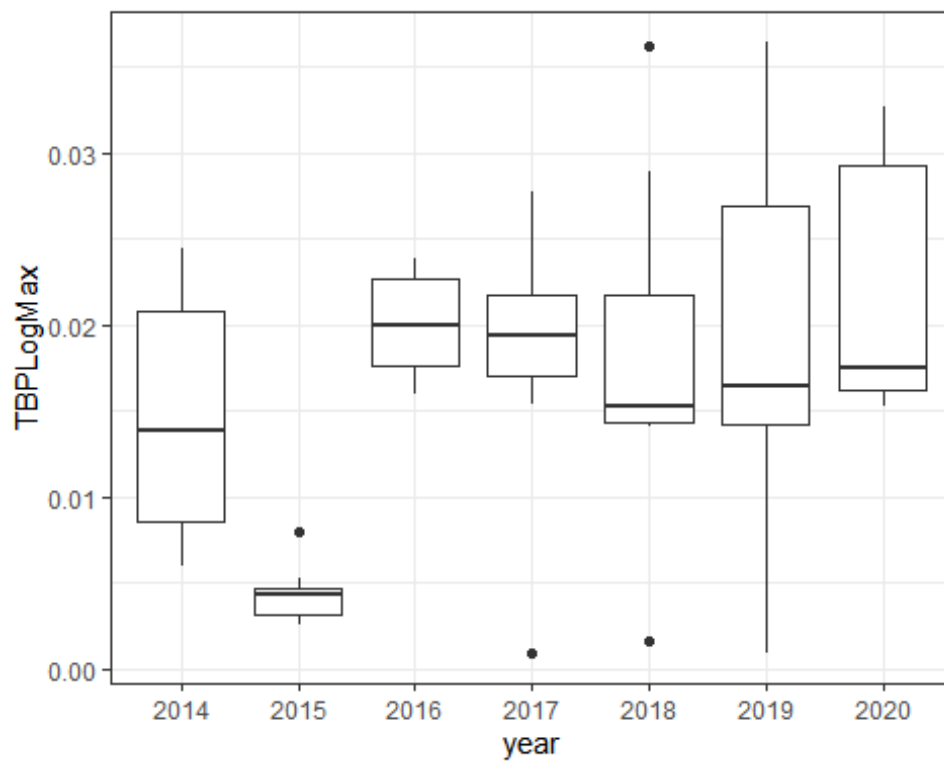
```
ggplot(PMdata, aes(x = year, y = TBLogAvr)) + geom_boxplot()
## Warning: Removed 7 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = year, y = TBPLogMax)) + geom_boxplot()
```

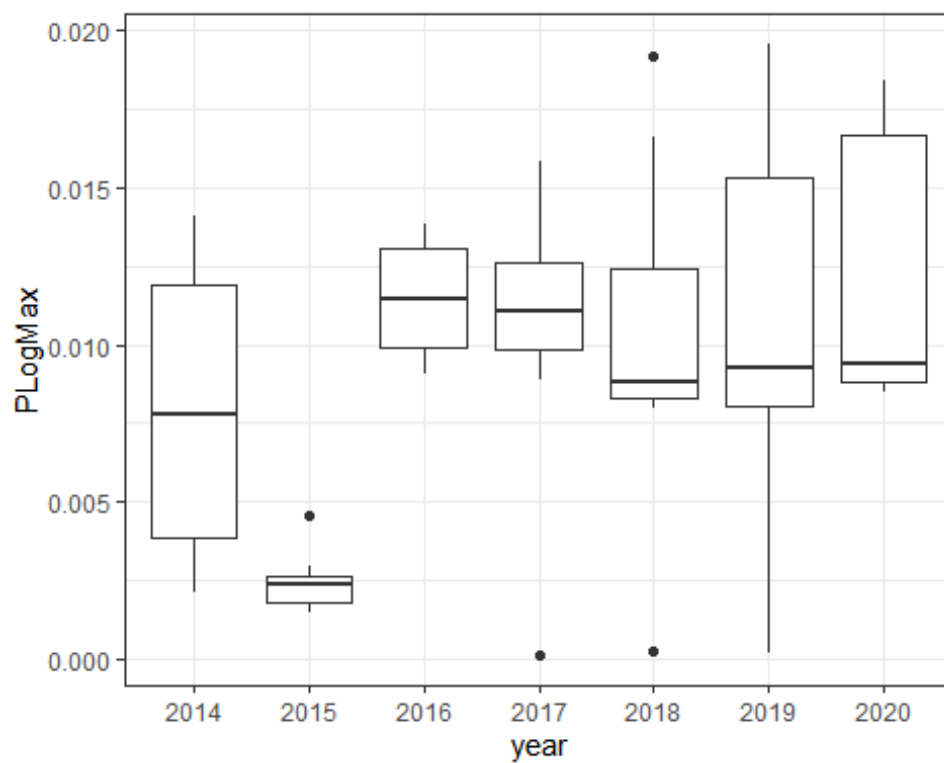


```
## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```

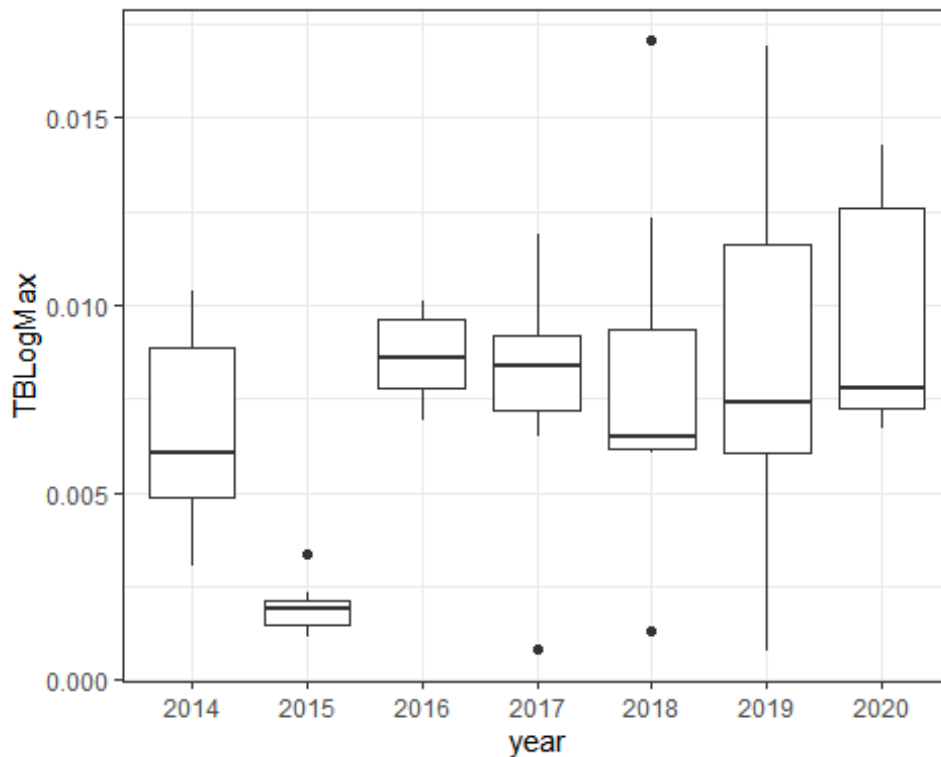


```
ggplot(PMdata, aes(x = year, y = PLogMax)) + geom_boxplot()
```

```
## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



```
ggplot(PMdata, aes(x = year, y = TBLogMax)) + geom_boxplot()
## Warning: Removed 16 rows containing non-finite values (stat_boxplot).
```



#VIF 1-5 - OK

```
M0 <- lm(PMdata$CountJ450 ~ year + code + TSPAavr, PMdata)
vif(M0)
```

```
##           GVIF Df GVIF^(1/(2*Df))
## year      2.319236  6          1.072619
## code      2.723828 14          1.036435
## TSPAavr    3.627946  1          1.904717
```

```
M0 <- lm(PMdata$CountJ450 ~ year + code + PM.10Aavr, PMdata)
vif(M0)
```

```
##           GVIF Df GVIF^(1/(2*Df))
## year      1.508705  6          1.034865
## code      3.222163 14          1.042673
## PM.10Aavr  3.216226  1          1.793384
```

```
M0 <- lm(PMdata$CountJ450 ~ year + code + PM.2.5Aavr, PMdata)
vif(M0)
```

```
##           GVIF Df GVIF^(1/(2*Df))
## year      2.294060  6          1.071644
## code      2.122750 14          1.027247
## PM.2.5Aavr 2.937106  1          1.713799
```

```
M0 <- lm(PMdata$CountJ450 ~ year + code + TSPMax, PMdata)
vif(M0)
```

```

##          GVIF Df GVIF^(1/(2*Df))
## year      1.236551 6          1.017851
## code      2.214889 14         1.028807
## TSPMax    2.044477 1          1.429852

M0 <- lm(PMdata$CountJ450 ~ year + code + PM.10Max, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.362715 6          1.026125
## code      2.119340 14         1.027188
## PM.10Max   2.070478 1          1.438916

M0 <- lm(PMdata$CountJ450 ~ year + code + PM.2.5Max, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.369672 6          1.026561
## code      1.900245 14         1.023193
## PM.2.5Max  1.875656 1          1.369546

M0 <- lm(PMdata$CountJ451 ~ year + code + TSPAavr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.319236 6          1.072619
## code      2.723828 14         1.036435
## TSPAavr    3.627946 1          1.904717

M0 <- lm(PMdata$CountJ451 ~ year + code + PM.10Avr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.508705 6          1.034865
## code      3.222163 14         1.042673
## PM.10Avr   3.216226 1          1.793384

M0 <- lm(PMdata$CountJ451 ~ year + code + PM.2.5Avr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.294060 6          1.071644
## code      2.122750 14         1.027247
## PM.2.5Avr  2.937106 1          1.713799

M0 <- lm(PMdata$CountJ451 ~ year + code + TSPMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.236551 6          1.017851
## code      2.214889 14         1.028807
## TSPMax    2.044477 1          1.429852

M0 <- lm(PMdata$CountJ451 ~ year + code + PM.10Max, PMdata)
vif(M0)

```

```
##          GVIF Df GVIF^(1/(2*Df))
## year      1.362715  6      1.026125
## code      2.119340 14      1.027188
## PM.10Max  2.070478  1      1.438916

M0 <- lm(PMdata$CountJ451 ~ year + code + PM.2.5Max, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.369672  6      1.026561
## code      1.900245 14      1.023193
## PM.2.5Max  1.875656  1      1.369546

M0 <- lm(PMdata$CountJ458 ~ year + code + TSPAavr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.319236  6      1.072619
## code      2.723828 14      1.036435
## TSPAavr    3.627946  1      1.904717

M0 <- lm(PMdata$CountJ458 ~ year + code + PM.10Avr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.508705  6      1.034865
## code      3.222163 14      1.042673
## PM.10Avr   3.216226  1      1.793384

M0 <- lm(PMdata$CountJ458 ~ year + code + PM.2.5Avr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.294060  6      1.071644
## code      2.122750 14      1.027247
## PM.2.5Avr  2.937106  1      1.713799

M0 <- lm(PMdata$CountJ458 ~ year + code + TSPMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.236551  6      1.017851
## code      2.214889 14      1.028807
## TSPMax     2.044477  1      1.429852

M0 <- lm(PMdata$CountJ458 ~ year + code + PM.10Max, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      1.362715  6      1.026125
## code      2.119340 14      1.027188
## PM.10Max  2.070478  1      1.438916

M0 <- lm(PMdata$CountJ458 ~ year + code + PM.2.5Max, PMdata)
vif(M0)
```

```
##          GVIF Df GVIF^(1/(2*Df))
## year      1.369672 6      1.026561
## code      1.900245 14     1.023193
## PM.2.5Max 1.875656 1      1.369546

M0 <- lm(PMdata$CountJ450 ~ year + code + TBPLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.576101 6      1.082049
## code      2.000551 14     1.025074
## TBPLogMax 2.841059 1      1.685544

M0 <- lm(PMdata$CountJ450 ~ year + code + PLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.540495 6      1.080795
## code      2.070456 14     1.026332
## PLogMax 2.868954 1      1.693799

M0 <- lm(PMdata$CountJ450 ~ year + code + TBLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.573374 6      1.081953
## code      1.886650 14     1.022930
## TBLogMax 2.744347 1      1.656607

M0 <- lm(PMdata$CountJ450 ~ year + code + TBPLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      4.962239 6      1.142808
## code      1.861119 14     1.022433
## TBPLogAvr 5.432090 1      2.330684

M0 <- lm(PMdata$CountJ450 ~ year + code + PLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      4.057578 6      1.123800
## code      1.782042 14     1.020849
## PLogAvr 4.497530 1      2.120738

M0 <- lm(PMdata$CountJ450 ~ year + code + TBLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      6.561277 6      1.169721
## code      1.981066 14     1.024716
## TBLogAvr 7.064311 1      2.657877

M0 <- lm(PMdata$CountJ451 ~ year + code + TBPLogMax, PMdata)
vif(M0)
```

```

##          GVIF Df GVIF^(1/(2*Df))
## year      2.576101 6      1.082049
## code      2.000551 14     1.025074
## TBPLogMax 2.841059 1      1.685544

M0 <- lm(PMdata$CountJ451 ~ year + code + PLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.540495 6      1.080795
## code      2.070456 14     1.026332
## PLogMax 2.868954 1      1.693799

M0 <- lm(PMdata$CountJ451 ~ year + code + TBLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.573374 6      1.081953
## code      1.886650 14     1.022930
## TBLogMax 2.744347 1      1.656607

M0 <- lm(PMdata$CountJ451 ~ year + code + TBPLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      4.962239 6      1.142808
## code      1.861119 14     1.022433
## TBPLogAvr 5.432090 1      2.330684

M0 <- lm(PMdata$CountJ451 ~ year + code + PLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      4.057578 6      1.123800
## code      1.782042 14     1.020849
## PLogAvr 4.497530 1      2.120738

M0 <- lm(PMdata$CountJ451 ~ year + code + TBLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      6.561277 6      1.169721
## code      1.981066 14     1.024716
## TBLogAvr 7.064311 1      2.657877

M0 <- lm(PMdata$CountJ458 ~ year + code + TBPLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.576101 6      1.082049
## code      2.000551 14     1.025074
## TBPLogMax 2.841059 1      1.685544

M0 <- lm(PMdata$CountJ458 ~ year + code + PLogMax, PMdata)
vif(M0)

```

```
##          GVIF Df GVIF^(1/(2*Df))
## year      2.540495 6      1.080795
## code      2.070456 14      1.026332
## PLogMax 2.868954 1      1.693799

M0 <- lm(PMdata$CountJ458 ~ year + code + TBLLogMax, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      2.573374 6      1.081953
## code      1.886650 14      1.022930
## TBLLogMax 2.744347 1      1.656607

M0 <- lm(PMdata$CountJ458 ~ year + code + TBPLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      4.962239 6      1.142808
## code      1.861119 14      1.022433
## TBPLogAvr 5.432090 1      2.330684

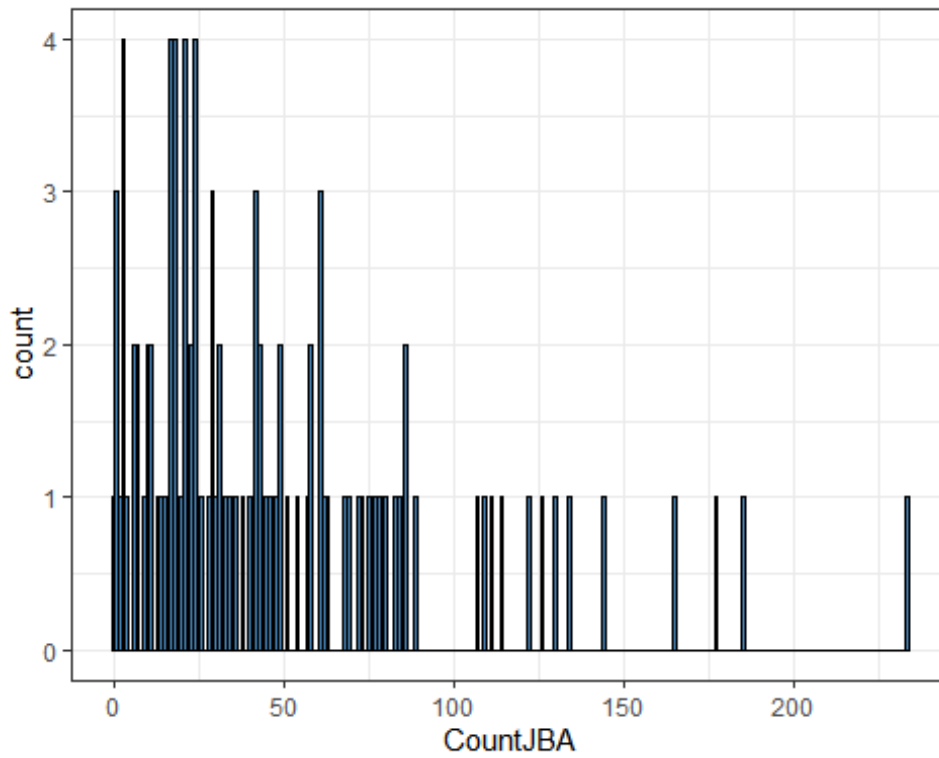
M0 <- lm(PMdata$CountJ458 ~ year + code + PLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      4.057578 6      1.123800
## code      1.782042 14      1.020849
## PLogAvr 4.497530 1      2.120738

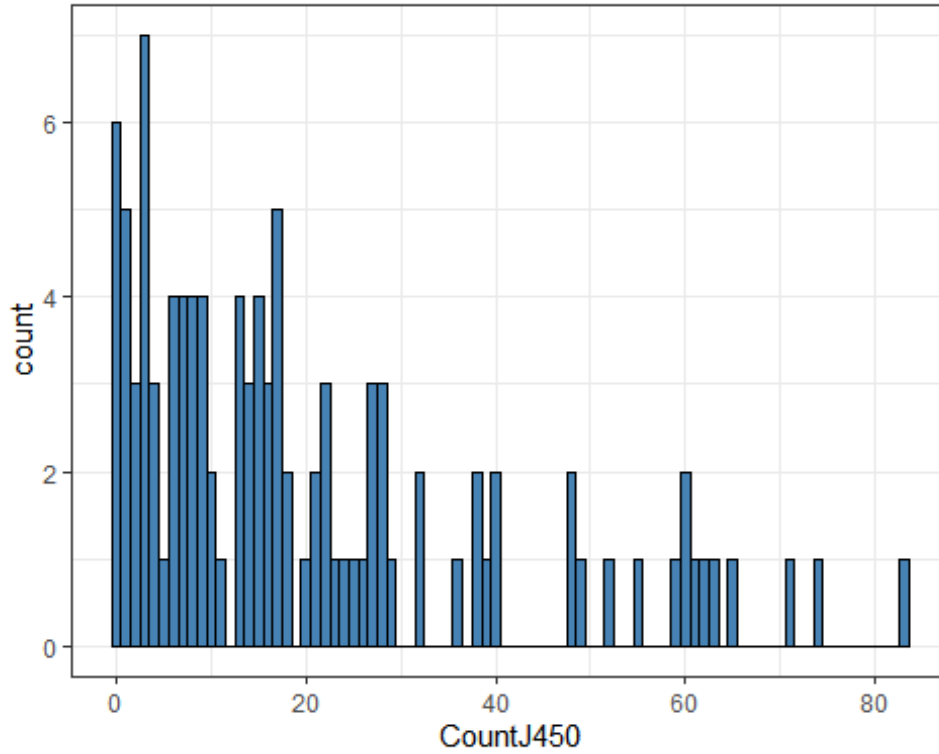
M0 <- lm(PMdata$CountJ458 ~ year + code + TBLLogAvr, PMdata)
vif(M0)

##          GVIF Df GVIF^(1/(2*Df))
## year      6.561277 6      1.169721
## code      1.981066 14      1.024716
## TBLLogAvr 7.064311 1      2.657877

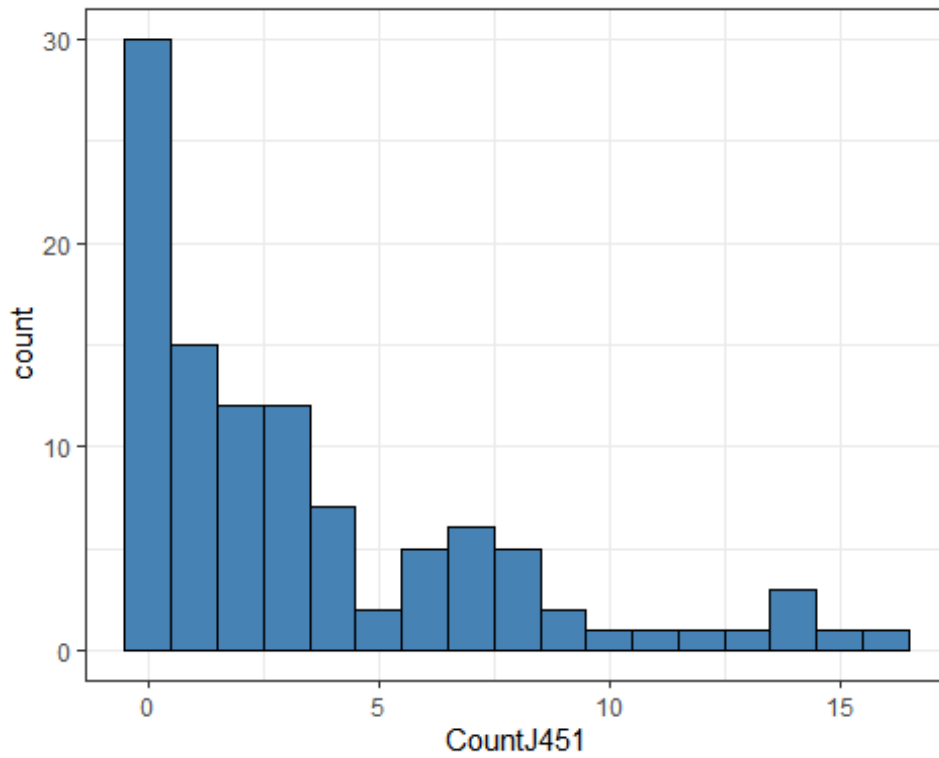
#Отклик - счетная переменная
ggplot(PMdata, aes(x = CountJBA)) +
  geom_histogram(binwidth = 1, fill = "steelblue", colour = "black")
```



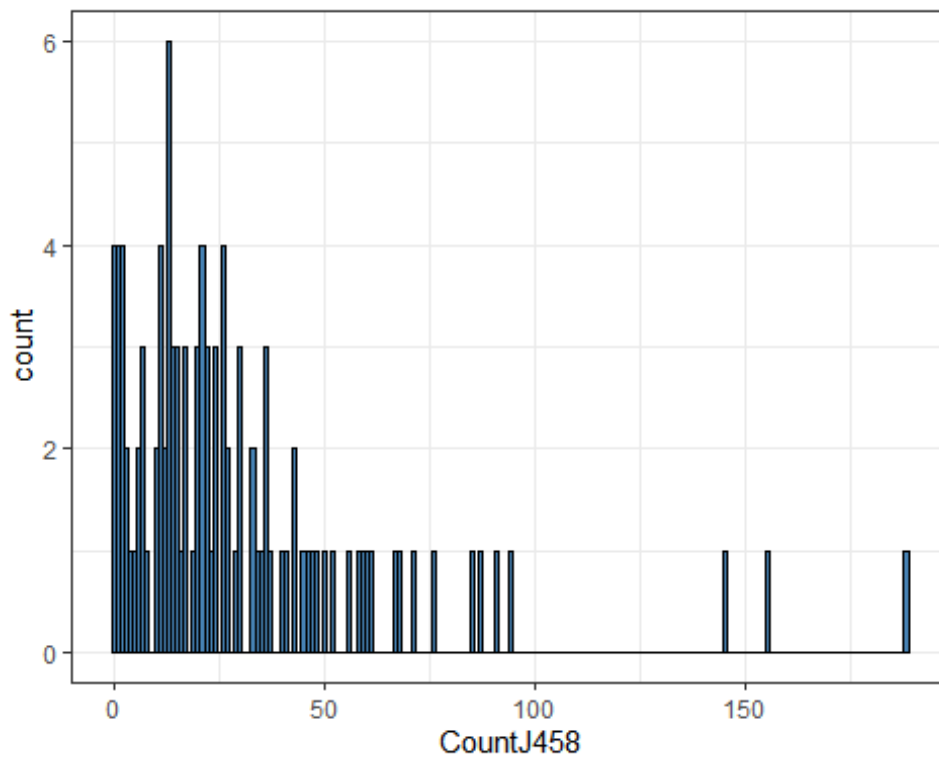
```
ggplot(PMdata, aes(x = CountJ450)) +  
  geom_histogram(binwidth = 1, fill = "steelblue", colour = "black")
```



```
ggplot(PMdata, aes(x = CountJ451)) +  
  geom_histogram(binwidth = 1, fill = "steelblue", colour = "black")
```

```
ggplot(PMdata, aes(x = CountJ458)) +  
  geom_histogram(binwidth = 1, fill = "steelblue", colour = "black")
```



```
#Доля нулей в счетных переменных  
mean(PMdata$CountJBA == 0)
```

```
## [1] 0.00952381
mean(PMdata$CountJ450 == 0)

## [1] 0.05714286
mean(PMdata$CountJ451 == 0)

## [1] 0.2857143
mean(PMdata$CountJ458 == 0)

## [1] 0.03809524

#Взаимодействия - ?

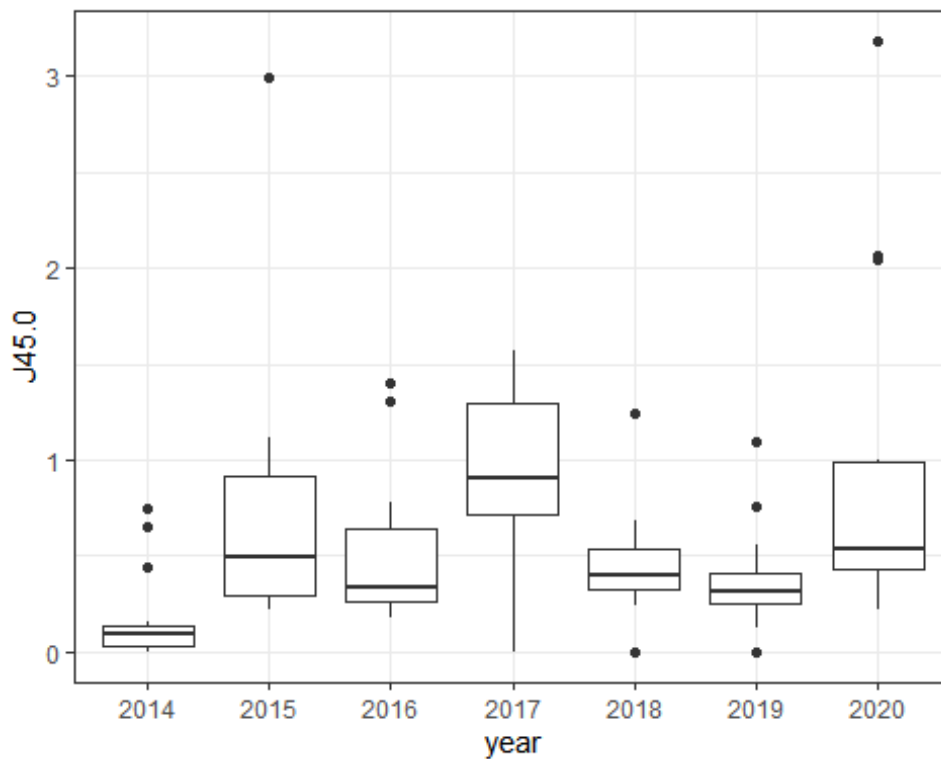
lPop <- log(PMdata$Pop)

#БА в мониторинговых точках в динамике лет
MJ450=glm(CountJ450 ~ year + code + offset(lPop), family="poisson", PMdata)
summary(MJ450)

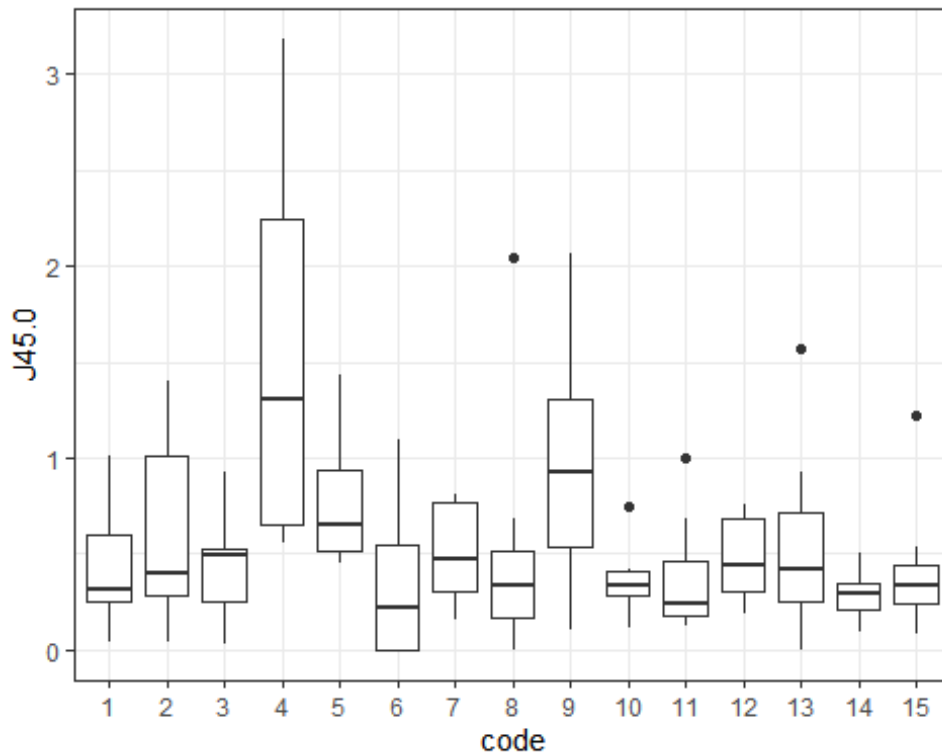
##
## Call:
## glm(formula = CountJ450 ~ year + code + offset(lPop), family = "poisson",
##      data = PMdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -3.8274  -1.6381  -0.4352   0.9294   6.3471
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -6.65847    0.12089  -55.080 < 2e-16 ***
## year2015     1.28402    0.11911   10.780 < 2e-16 ***
## year2016     1.18036    0.12052    9.794 < 2e-16 ***
## year2017     1.82634    0.11358   16.080 < 2e-16 ***
## year2018     1.06854    0.12218    8.746 < 2e-16 ***
## year2019     0.91184    0.12480    7.306 2.75e-13 ***
## year2020     1.47908    0.11680   12.663 < 2e-16 ***
## code2         0.36698    0.09078    4.042 5.29e-05 ***
## code3        -0.00457    0.12181   -0.038 0.970070
## code4         1.26604    0.14563    8.693 < 2e-16 ***
## code5         0.57727    0.12599    4.582 4.61e-06 ***
## code6        -0.24298    0.30800   -0.789 0.430168
## code7         0.15651    0.08619    1.816 0.069388 .
## code8         0.20031    0.30802    0.650 0.515498
## code9         0.79604    0.09510    8.370 < 2e-16 ***
## code10        -0.17143    0.08954   -1.915 0.055543 .
## code11        -0.14680    0.13827   -1.062 0.288393
## code12         0.09313    0.08972    1.038 0.299287
## code13         0.24907    0.10999    2.264 0.023549 *
## code14        -0.43039    0.12435   -3.461 0.000538 ***
## code15        -0.02300    0.10270   -0.224 0.822805
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##      Null deviance: 1108.11  on 104  degrees of freedom
## Residual deviance:  444.51  on  84  degrees of freedom
## AIC: 927.4
##
## Number of Fisher Scoring iterations: 5

ggplot(PMdata, aes(x = year, y = J45.0)) + geom_boxplot()
```



```
ggplot(PMdata, aes(x = code, y = J45.0)) + geom_boxplot()
```

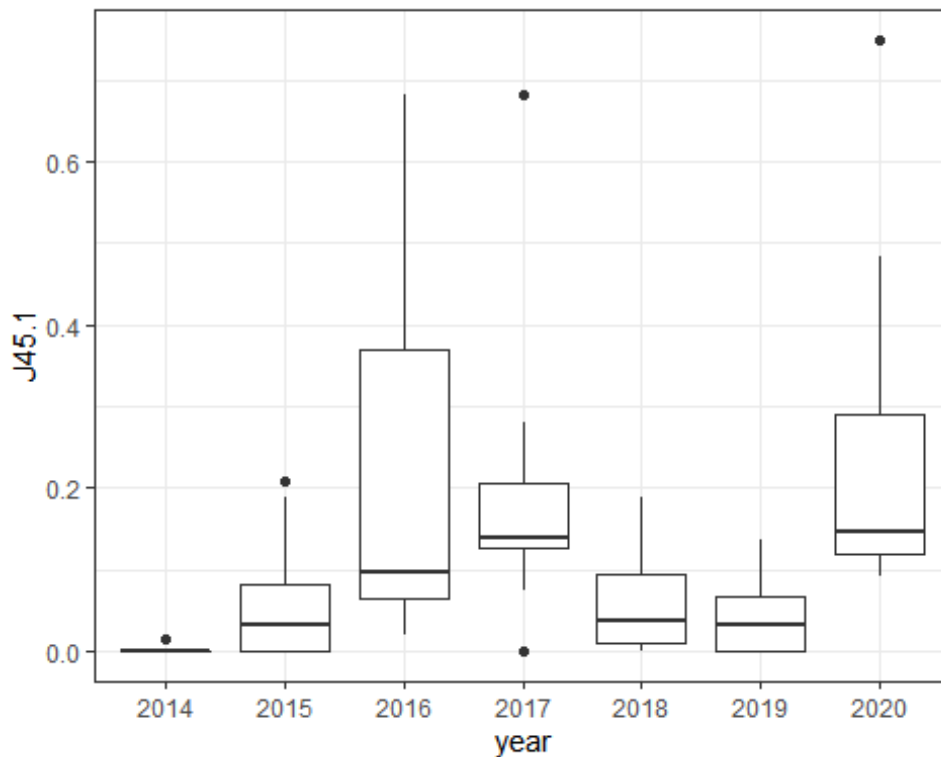


```
MJ451=glm(CountJ451 ~ year + code + offset(lPop),family="poisson",PMdata)
summary(MJ451)
```

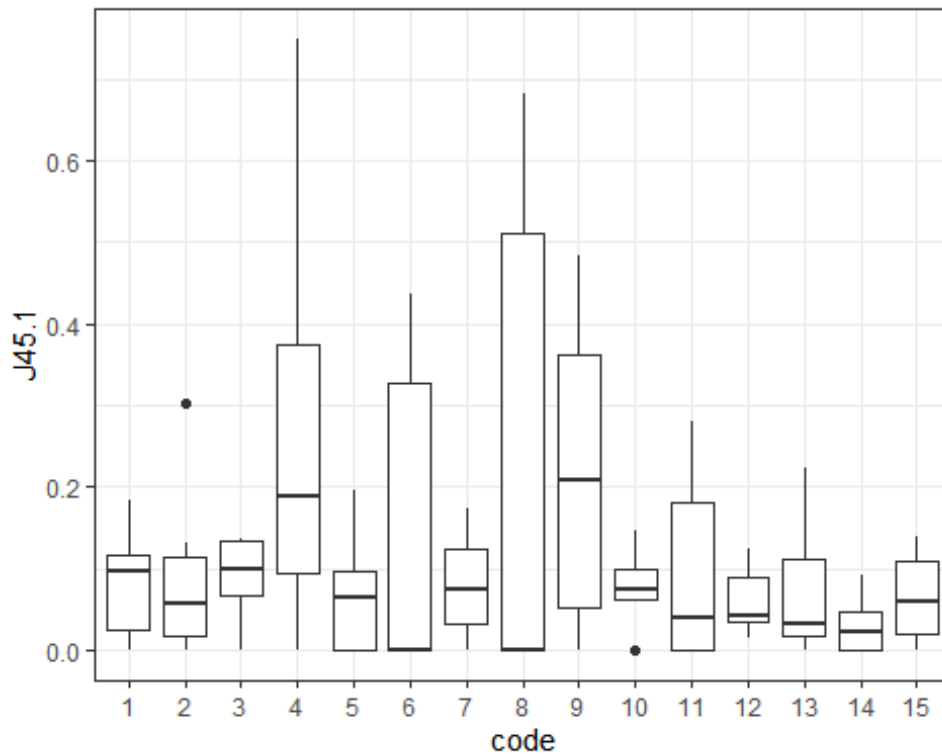
```
##
## Call:
## glm(formula = CountJ451 ~ year + code + offset(lPop), family = "poisson",
##      data = PMdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -2.7452  -0.9254  -0.2236   0.5856   2.8589
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -11.078423   1.009443  -10.975  < 2e-16 ***
## year2015      3.496508   1.015038   3.445 0.000572 ***
## year2016      4.356709   1.006389   4.329 1.50e-05 ***
## year2017      4.406719   1.006079   4.380 1.19e-05 ***
## year2018      3.583519   1.013793   3.535 0.000408 ***
## year2019      3.433987   1.016001   3.380 0.000725 ***
## year2020      4.615121   1.004938   4.592 4.38e-06 ***
## code2          0.108957   0.228128   0.478 0.632926
## code3          0.118868   0.272710   0.436 0.662927
## code4          1.208968   0.348911   3.465 0.000530 ***
## code5         -0.206849   0.405705  -0.510 0.610155
## code6          0.669347   0.470892   1.421 0.155187
## code7         -0.002468   0.209670  -0.012 0.990609
## code8          1.112637   0.470892   2.363 0.018136 *
## code9          0.997813   0.210871   4.732 2.22e-06 ***
```

```
## code10      -0.028784    0.202410   -0.142  0.886916
## code11       0.197547    0.283836    0.696  0.486435
## code12      -0.273356    0.232373   -1.176  0.239448
## code13      -0.089741    0.290240   -0.309  0.757173
## code14      -0.998286    0.364486   -2.739  0.006165 **
## code15      -0.210597    0.255377   -0.825  0.409569
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##      Null deviance: 361.92  on 104  degrees of freedom
## Residual deviance: 115.99  on  84  degrees of freedom
## AIC: 393.81
##
## Number of Fisher Scoring iterations: 6

ggplot(PMdata, aes(x = year, y = J45.1)) + geom_boxplot()
```



```
ggplot(PMdata, aes(x = code, y = J45.1)) + geom_boxplot()
```

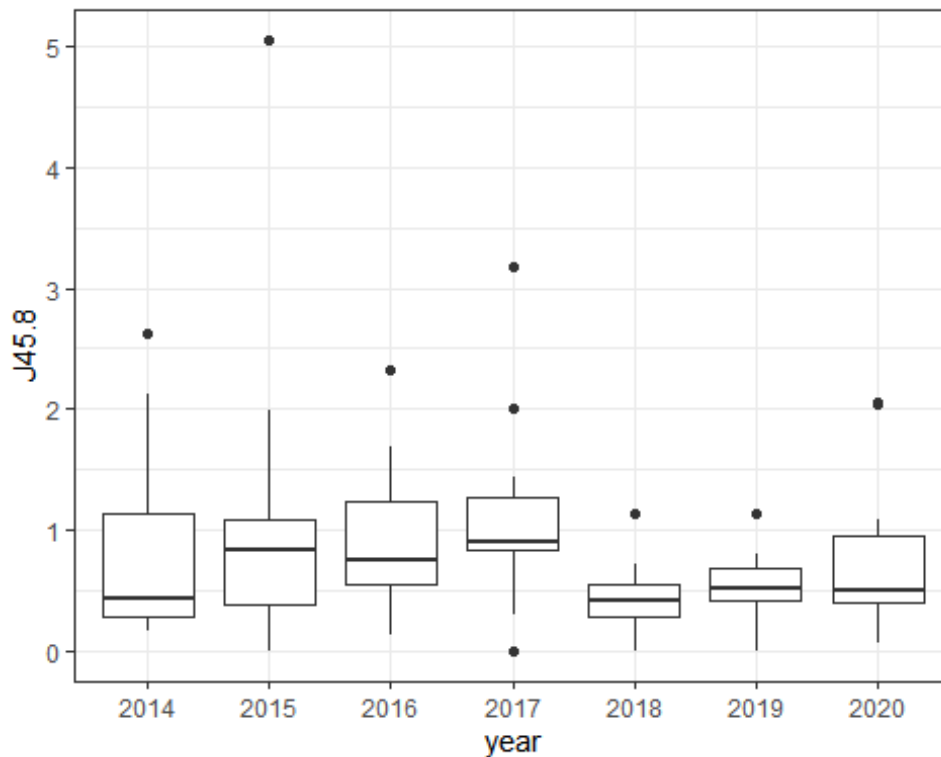


```
MJ458=glm(CountJ458 ~ year + code + offset(lPop),family="poisson",PMdata)
summary(MJ458)
```

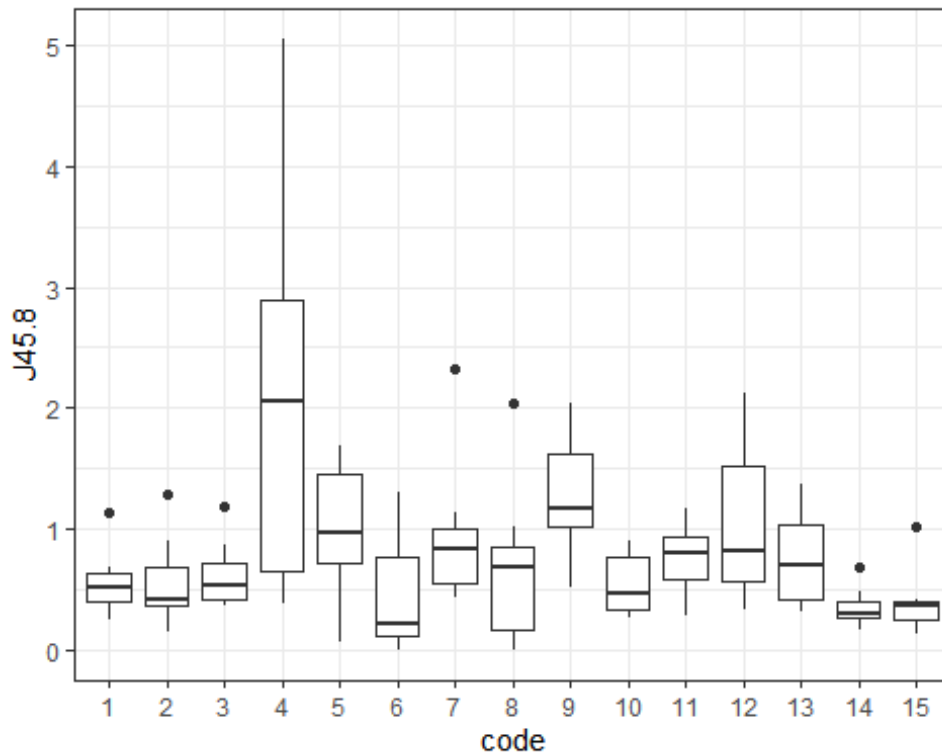
```
##
## Call:
## glm(formula = CountJ458 ~ year + code + offset(lPop), family = "poisson",
##      data = PMdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -4.9293  -2.1741  -0.3825   1.2924   8.6275
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -5.25738    0.07186  -73.161  < 2e-16 ***
## year2015      0.27483    0.06543   4.200 2.67e-05 ***
## year2016      0.34788    0.06443   5.399 6.69e-08 ***
## year2017      0.40951    0.06363   6.436 1.23e-10 ***
## year2018     -0.40912    0.07808  -5.240 1.61e-07 ***
## year2019     -0.10239    0.07161  -1.430 0.152782
## year2020     -0.16639    0.07285  -2.284 0.022365 *
## code2        -0.01439    0.08864  -0.162 0.871075
## code3         0.08525    0.10336   0.825 0.409451
## code4         1.29872    0.12597  10.309 < 2e-16 ***
## code5         0.57422    0.11056   5.194 2.06e-07 ***
## code6        -0.19641    0.26403  -0.744 0.456941
## code7         0.52176    0.06996   7.458 8.75e-14 ***
## code8         0.17788    0.27290   0.652 0.514519
## code9         0.81377    0.08295   9.811 < 2e-16 ***
```

```
## code10      -0.03904    0.07598  -0.514  0.607413
## code11       0.28276    0.10308   2.743  0.006083 **
## code12       0.62355    0.06996   8.914  < 2e-16 ***
## code13       0.28529    0.09525   2.995  0.002744 **
## code14      -0.47775    0.11094  -4.306  1.66e-05 ***
## code15      -0.34065    0.09997  -3.408  0.000655 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
## Null deviance: 1385.9  on 104  degrees of freedom
## Residual deviance: 691.5  on  84  degrees of freedom
## AIC: 1218.8
##
## Number of Fisher Scoring iterations: 5

ggplot(PMdata, aes(x = year, y = J45.8)) + geom_boxplot()
```



```
ggplot(PMdata, aes(x = code, y = J45.8)) + geom_boxplot()
```



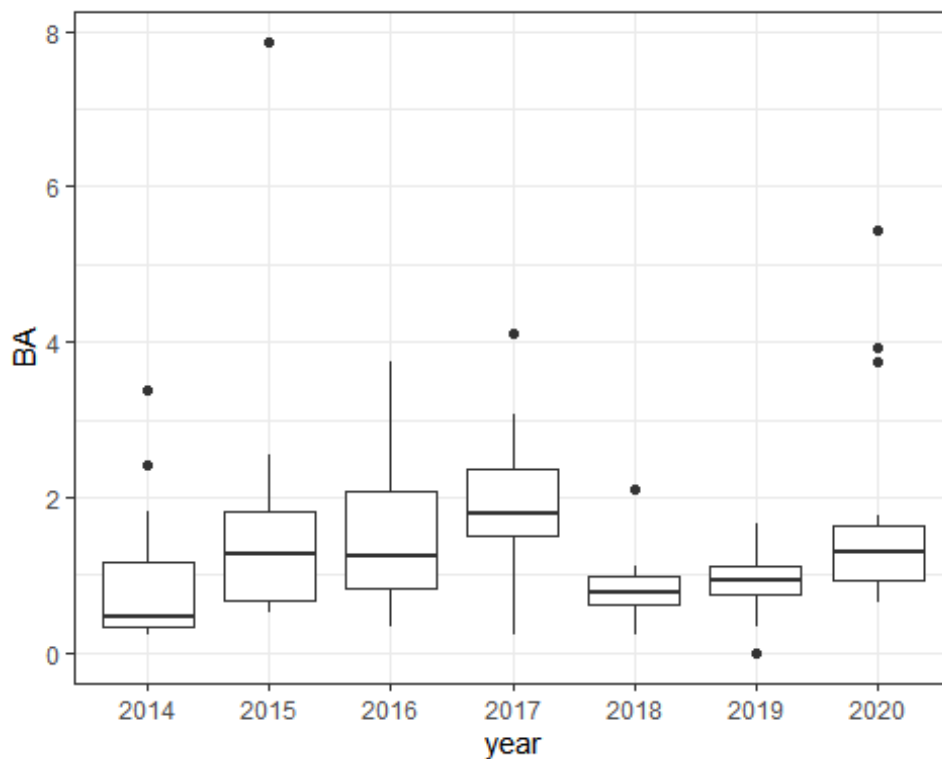
```
MBA=glm(CountJBA ~ year + code + offset(lPop),family="poisson",PMdata)
summary(MBA)
```

```
##
## Call:
## glm(formula = CountJBA ~ year + code + offset(lPop), family = "poisson",
##      data = PMdata)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -5.3088  -2.2837  -0.6414   1.2947  10.5269
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.038698   0.060535 -83.237  < 2e-16 ***
## year2015     0.549402   0.057444   9.564  < 2e-16 ***
## year2016     0.554222   0.057393   9.657  < 2e-16 ***
## year2017     0.829812   0.054813  15.139  < 2e-16 ***
## year2018     0.040989   0.064032   0.640  0.52208
## year2019     0.196860   0.061727   3.189  0.00143 **
## year2020     0.449128   0.058542   7.672 1.69e-14 ***
## code2         0.095729   0.065345   1.465  0.14292
## code3         0.008579   0.080960   0.106  0.91561
## code4         1.361043   0.093610  14.539  < 2e-16 ***
## code5         0.537553   0.085409   6.294 3.10e-10 ***
## code6        -0.080979   0.190401  -0.425  0.67061
## code7         0.321253   0.055487   5.790 7.05e-09 ***
## code8         0.253111   0.200578   1.262  0.20698
## code9         0.794483   0.063541  12.503  < 2e-16 ***
```

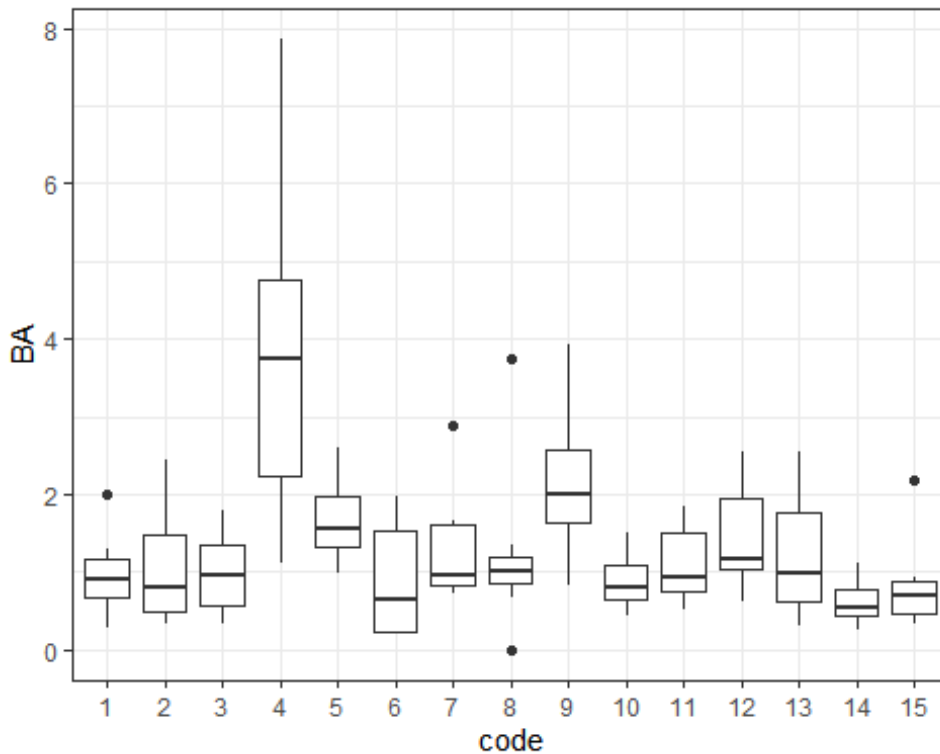


```
## code10      -0.097972    0.058718   -1.669    0.09521 .
## code11       0.129149    0.083055    1.555    0.11995
## code12       0.409865    0.055643    7.366 1.76e-13 ***
## code13       0.231605    0.073891    3.134  0.00172 **
## code14      -0.456671    0.083863   -5.445 5.17e-08 ***
## code15      -0.153832    0.071515   -2.151  0.03147 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for poisson family taken to be 1)
##
##    Null deviance: 1874.75  on 104  degrees of freedom
## Residual deviance:  910.26  on  84  degrees of freedom
## AIC: 1497.7
##
## Number of Fisher Scoring iterations: 5

ggplot(PMdata, aes(x = year, y = BA)) + geom_boxplot()
```



```
ggplot(PMdata, aes(x = code, y = BA)) + geom_boxplot()
```



```
PMdataAdd <- read.csv('PMdata4.csv', header=TRUE, sep=';', dec = ",")
PMdataAdd$code <- as.factor(PMdataAdd$code)
```

```
MJ450.1=lm(J45.0 ~ year + code, PMdataAdd)
summary(MJ450.1)
```

```
##
## Call:
## lm(formula = J45.0 ~ year + code, data = PMdataAdd)
##
## Residuals:
```

	Min	1Q	Median	3Q	Max
	-1.09658	-0.22871	-0.08378	0.15643	1.55117

```
##
## Coefficients:
```

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-1.077e+02	4.736e+01	-2.274	0.0254 *
year	5.360e-02	2.348e-02	2.283	0.0248 *
code2	1.926e-01	2.572e-01	0.749	0.4559
code3	-4.404e-03	2.572e-01	-0.017	0.9864
code4	1.113e+00	2.572e-01	4.329	3.91e-05 ***
code5	3.419e-01	2.572e-01	1.329	0.1871
code6	-9.430e-02	2.572e-01	-0.367	0.7147
code7	7.411e-02	2.572e-01	0.288	0.7739
code8	9.734e-02	2.572e-01	0.378	0.7060
code9	5.323e-01	2.572e-01	2.070	0.0414 *
code10	-6.892e-02	2.572e-01	-0.268	0.7893
code11	-5.967e-02	2.572e-01	-0.232	0.8171
code12	4.274e-02	2.572e-01	0.166	0.8684

```
## code13      1.237e-01  2.572e-01   0.481   0.6316
## code14     -1.530e-01  2.572e-01  -0.595   0.5534
## code15     -9.944e-03  2.572e-01  -0.039   0.9692
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4812 on 89 degrees of freedom
## Multiple R-squared:  0.3551, Adjusted R-squared:  0.2464
## F-statistic: 3.266 on 15 and 89 DF,  p-value: 0.0002465

MJ451.1=lm(J45.1 ~ year + code, PMdataAdd)
summary(MJ451.1)

##
## Call:
## lm(formula = J45.1 ~ year + code, data = PMdataAdd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.30472 -0.05224 -0.00871  0.04147  0.45623
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -3.756e+01  1.400e+01  -2.683  0.00869 **
## year         1.866e-02  6.939e-03   2.689  0.00855 **
## code2        8.921e-03  7.602e-02   0.117  0.90684
## code3        1.054e-02  7.602e-02   0.139  0.89000
## code4        1.875e-01  7.602e-02   2.467  0.01553 *
## code5       -1.491e-02  7.602e-02  -0.196  0.84495
## code6        7.613e-02  7.602e-02   1.001  0.31931
## code7       -1.976e-04  7.602e-02  -0.003  0.99793
## code8        1.632e-01  7.602e-02   2.147  0.03448 *
## code9        1.367e-01  7.602e-02   1.799  0.07544 .
## code10      -2.267e-03  7.602e-02  -0.030  0.97628
## code11       1.746e-02  7.602e-02   0.230  0.81890
## code12      -1.909e-02  7.602e-02  -0.251  0.80225
## code13      -6.853e-03  7.602e-02  -0.090  0.92837
## code14      -5.043e-02  7.602e-02  -0.663  0.50880
## code15     -1.516e-02  7.602e-02  -0.199  0.84234
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1422 on 89 degrees of freedom
## Multiple R-squared:  0.2698, Adjusted R-squared:  0.1467
## F-statistic: 2.192 on 15 and 89 DF,  p-value: 0.01214

MJ458.1=lm(J45.8 ~ year + code, PMdataAdd)
summary(MJ458.1)

##
## Call:
## lm(formula = J45.8 ~ year + code, data = PMdataAdd)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.65998 -0.31860 -0.09628  0.27097  2.86537
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 104.242876  61.807658   1.687   0.0952 .
## year        -0.051400   0.030643  -1.677   0.0970 .
## code2        -0.008952   0.335679  -0.027   0.9788
## code3         0.051086   0.335679   0.152   0.8794
## code4         1.516339   0.335679   4.517 1.92e-05 ***
## code5         0.441891   0.335679   1.316   0.1914
## code6        -0.101446   0.335679  -0.302   0.7632
## code7         0.390028   0.335679   1.162   0.2484
## code8         0.111260   0.335679   0.331   0.7411
## code9         0.715397   0.335679   2.131   0.0358 *
## code10        -0.021806   0.335679  -0.065   0.9484
## code11         0.186196   0.335679   0.555   0.5805
## code12         0.492929   0.335679   1.468   0.1455
## code13         0.187995   0.335679   0.560   0.5769
## code14        -0.216289   0.335679  -0.644   0.5210
## code15        -0.164379   0.335679  -0.490   0.6256
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.628 on 89 degrees of freedom
## Multiple R-squared:  0.3644, Adjusted R-squared:  0.2573
## F-statistic: 3.402 on 15 and 89 DF,  p-value: 0.0001504

MBA.1=lm(BA ~ year + code, PMdataAdd)
summary(MBA.1)

##
## Call:
## lm(formula = BA ~ year + code, data = PMdataAdd)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.7160 -0.4707 -0.1647  0.3172  4.0530
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -14.376829  91.996205  -0.156   0.8762
## year         0.007614   0.045610   0.167   0.8678
## code2        0.098245   0.499633   0.197   0.8446
## code3        0.007167   0.499633   0.014   0.9886
## code4        2.843029   0.499633   5.690 1.6e-07 ***
## code5        0.698474   0.499633   1.398   0.1656
## code6       -0.076115   0.499633  -0.152   0.8793
## code7        0.371577   0.499633   0.744   0.4590
## code8        0.283257   0.499633   0.567   0.5722
## code9        1.190038   0.499633   2.382   0.0194 *
## code10       -0.091546   0.499633  -0.183   0.8550
```

```
## code11      0.135394    0.499633    0.271    0.7870
## code12      0.497027    0.499633    0.995    0.3225
## code13      0.255645    0.499633    0.512    0.6102
## code14     -0.359613    0.499633   -0.720    0.4736
## code15     -0.139845    0.499633   -0.280    0.7802
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9347 on 89 degrees of freedom
## Multiple R-squared:  0.4345, Adjusted R-squared:  0.3392
## F-statistic: 4.559 on 15 and 89 DF,  p-value: 2.419e-06
```

#Линейные модели - не соответствуют структуре данных

#Линейная модель + Модель со случайным эффектом

#Аллергическая БА J45.0

#Неаллергическая БА J45.1

```
#mod1 <- lm(J45.0 ~ PM.2.5Max + year + code, PMdata)
```

```
#anova(mod1)
```

```
#summary(mod1)
```

```
#mod2 <- lm(J45.0 ~ PM.2.5Max * code + year, PMdata)
```

```
#anova(mod2)
```

```
#summary(mod2)
```

```
#mod3 <- lm(J45.0 ~ PM.2.5Max * year + code, PMdata)
```

```
#anova(mod3)
```

```
#summary(mod3)
```

```
#mod4.0 <- lmer(J45.0 ~ 1 + (1+PM.2.5Max|year) + code, PMdata, REML=FALSE)
```

```
#summary(mod4.0)
```

```
#mod4.0.1 <- lmer(J45.0 ~ PM.2.5Max + (1+PM.2.5Max|year) + code, PMdata, REML=FALSE)
```

```
#summary(mod4.0.1)
```

```
#anova(mod4.0, mod4.0.1)
```

```
#mod1.1 <- lm(J45.1 ~ PM.2.5Max + year + code, PMdata)
```

```
#anova(mod1.1)
```

```
#summary(mod1.1)
```

```
#mod2.1 <- lm(J45.1 ~ PM.2.5Max * code + year, PMdata)
```

```
#anova(mod2.1)
```

```
#summary(mod2.1)
```

```
#mod3.1 <- lm(J45.1 ~ PM.2.5Max * year + code, PMdata)
```

```
#anova(mod3.1)
```

```
#summary(mod3.1)
```

```
#mod4.1 <- lmer(J45.1 ~ 1 + (1+PM.2.5Max|year) + code, PMdata, REML=FALSE)
```

```
#summary(mod4.1)
```

```
#mod4.1.1 <- lmer(J45.1 ~ PM.2.5Max + (1+PM.2.5Max|year) + code, PMdata, REML=FALSE)
```

```

LSE)
#summary(mod4.1.1)
#anova(mod4.1, mod4.1.1)

#mod4.1.10 <- lmer(J45.1 ~ 1 + (1+PM.10Max|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.10)
#mod4.1.1.10 <- lmer(J45.1 ~ PM.10Max + (1+PM.10Max|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.1.10)
#anova(mod4.1.10, mod4.1.1.10)

#mod4.1.TSP <- lmer(J45.1 ~ 1 + (1+TSPMax|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.TSP)
#mod4.1.1.TSP <- lmer(J45.1 ~ TSPMax + (1+TSPMax|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.1.TSP)
#anova(mod4.1.TSP, mod4.1.1.TSP)

#mod1a <- lm(J45.0 ~ PM.2.5Avr + year + code, PMdata)
#anova(mod1a)
#summary(mod1a)

#mod2a <- lm(J45.0 ~ PM.2.5Avr * code + year, PMdata)
#anova(mod2a)
#summary(mod2a)

#mod3a <- lm(J45.0 ~ PM.2.5Avr * year + code, PMdata)
#anova(mod3a)
#summary(mod3a)

#mod4.0.a <- lmer(J45.0 ~ 1 + (1+PM.2.5Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.0.a)
#mod4.0.1a <- lmer(J45.0 ~ PM.2.5Avr + (1+PM.2.5Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.0.1a)
#anova(mod4.0.a, mod4.0.1a)

#mod1.1a <- lm(J45.1 ~ PM.2.5Avr + year + code, PMdata)
#anova(mod1.1a)
#summary(mod1.1a)

#mod2.1a <- lm(J45.1 ~ PM.2.5Avr * code + year, PMdata)
#anova(mod2.1a)
#summary(mod2.1a)

#mod3.1a <- lm(J45.1 ~ PM.2.5Avr * year + code, PMdata)
#anova(mod3.1a)
#summary(mod3.1a)

#mod4.1a <- lmer(J45.1 ~ 1 + (1+PM.2.5Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1a)

```

```

#mod4.1.1a <- lmer(J45.1 ~ PM.2.5Avr + (1+PM.2.5Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.1a)
#anova(mod4.1a, mod4.1.1a)

#mod4.1a <- lmer(J45.1 ~ 1 + (1+PM.2.5Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1a)
#mod4.1.1a <- lmer(J45.1 ~ PM.2.5Avr + (1+PM.2.5Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.1a)
#anova(mod4.1a, mod4.1.1a)

#mod4.1.10a <- lmer(J45.1 ~ 1 + (1+PM.10Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.10a)
#mod4.1.1.10a <- lmer(J45.1 ~ PM.10Max + (1+PM.10Avr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.1.10a)
#anova(mod4.1.10a, mod4.1.1.10a)

#mod4.1.TSPa <- lmer(J45.1 ~ 1 + (1+TSPAvr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.TSPa)
#mod4.1.1.TSPa <- lmer(J45.1 ~ TSPAvr + (1+TSPAvr|year) + code, PMdata, REML=FALSE)
#summary(mod4.1.1.TSPa)
#anova(mod4.1.TSPa, mod4.1.1.TSPa)

#Визуальная проверка на гетероскедастичность

#mod1_diag <- fortify(mod1)
#ggplot(mod1_diag, aes(x = .fitted, y = .stdresid)) +
#geom_point() +
#geom_hline(yintercept = 0)

#ggqqplot(data$PM.2.5Max)

#mod1_diag <- fortify(mod2)
#ggplot(mod1_diag, aes(x = .fitted, y = .stdresid)) +
#geom_point() +
#geom_hline(yintercept = 0)

#ggqqplot(data$PM.2.5Max)

#mod1_diag <- fortify(mod3)
#ggplot(mod1_diag, aes(x = .fitted, y = .stdresid)) +
#geom_point() +
#geom_hline(yintercept = 0)

#ggqqplot(data$PM.2.5Max)

#mod1_diag <- fortify(mod1.1)
#ggplot(mod1_diag, aes(x = .fitted, y = .stdresid)) +

```

```

#geom_point() +
#geom_hline(yintercept = 0)

#ggqqplot(data$PM.2.5Max)

#mod1_diag <- fortify(mod2.1)
#ggplot(mod1_diag, aes(x = .fitted, y = .stdresid)) +
#geom_point() +
#geom_hline(yintercept = 0)

#ggqqplot(data$PM.2.5Max)

#mod1_diag <- fortify(mod3.1)
#ggplot(mod1_diag, aes(x = .fitted, y = .stdresid)) +
#geom_point() +
#geom_hline(yintercept = 0)

#ggqqplot(data$PM.2.5Max)

```

#Пуассоновские модели

*#Когда модель построена, нужно остатки пирсоновские посмотреть, у них распределение должно быть нормальное (0,1),
#дисперсии одинаковые относительно всех переменных, и т.д. Т.е. протокол соблюсти на предмет валидности.*

*#если дисперсия остатков избыточная (но примерно одинаковая), то можно посмотреть на NB (Negative Binomial) вместо пуассона,
#только параметр theta придется подбирать по AIC или еще как*

#фиксированный эффект взвешенных частиц, года и точки - не соответствует типу данных

```

#M1.0=glm(CountJ450 ~ PM.2.5Max + year + code +offset(LPop),family="poisson",PMdata)
#summary(M1.0)
#M1=glm(CountJ451 ~ PM.2.5Max + year + code +offset(LPop),family="poisson",PMdata)
#summary(M1)

```

#фиксированный эффект взвешенных частиц и точки, случайный эффект года

```

#Ручной подсчет сверхдисперсии (при необходимости)
#R_M <- resid(M, type = "pearson") # Пирсоновские остатки
#N <- nrow(data) # Объем выборки, но не учитывает строки с пропущенными данными
#p <- length(fixef(M))+2# Число параметров (не забудьте сл. эффект! или эффекты - у нас их 2)
#df <- (N - p) # число степеней свободы

```



```

#overdispersion <- sum(R_M^2) /df # во сколько раз var(y) > E(y)
#overdispersion
#pchisq(sum(R_M^2), df = df, Lower.tail = FALSE)

OverDisp1 <- function(x) {
  R_M <- resid(x, type = "pearson") # Пирсоновские остатки
  N <- nrow(data) # Объем выборки, но не учитывает строки с пропущенными данными
  p <- length(fixef(x))+1# Число параметров (не забудьте сл. эффект! или эффекты
- у нас их 2)
  df <- (N - p) # число степеней свободы
  overdispersion <- sum(R_M^2) /df # во сколько раз var(y) > E(y)
  overdispersion
  pchisq(sum(R_M^2), df = df, lower.tail = FALSE)
}

OverDisp2 <- function(x) {
  R_M <- resid(x, type = "pearson") # Пирсоновские остатки
  N <- nrow(data) # Объем выборки, но не учитывает строки с пропущенными данными
  p <- length(fixef(x))+2# Число параметров (не забудьте сл. эффект! или эффекты
- у нас их 2)
  df <- (N - p) # число степеней свободы
  overdispersion <- sum(R_M^2) /df # во сколько раз var(y) > E(y)
  overdispersion
  pchisq(sum(R_M^2), df = df, lower.tail = FALSE)
}

#Диагностика модели (анализ остатков)
model_diag <- function(model) {
  model_diag <- data.frame(
    PMdataComplete,
    .fitted = fitted(model),
    .resid = resid(model, type = 'pearson'),
    .sresid = resid(model, type = 'pearson', scaled = TRUE)
  )

  #.fitted - предсказанные значения,
  #.resid - Пирсоновские остатки,
  #.sresid - стандартизованные Пирсоновские остатки

  #График остатков от предсказанных значений
  gg_resid <- ggplot(model_diag, aes(y = .sresid)) +
    geom_hline(yintercept = 0)
  gg_resid + geom_point(aes(x = .fitted))
}

model_diag1 <- function(model) {
  model_diag1 <- data.frame(
    data,
    .fitted = fitted(model),
    .resid = resid(model, type = 'pearson'),
    .sresid = resid(model, type = 'pearson', scaled = TRUE)
  )
}

```

```

)

#fitted - предсказанные значения,
#resid - Пирсоновские остатки,
#scredid - стандартизованные Пирсоновские остатки

#График остатков от предсказанных значений
gg_resid <- ggplot(model_diag1, aes(y = .scredid)) +
  geom_hline(yintercept = 0) +
  facet_grid(code ~ year)
gg_resid + geom_point(aes(x = .fitted))
}

model_diag3 <- function(model) {
  model_diag <- data.frame(
    .fitted = fitted(model),
    .resid = resid(model, type = 'pearson'),
    .scredid = resid(model, type = 'pearson', scaled = TRUE)
  )

  #fitted - предсказанные значения,
  #resid - Пирсоновские остатки,
  #scredid - стандартизованные Пирсоновские остатки

  #График остатков от предсказанных значений
  gg_resid <- ggplot(model_diag, aes(y = .scredid)) +
    geom_hline(yintercept = 0)
  gg_resid + geom_point(aes(x = .fitted))
}

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M0=glmer(CountJBA~code+PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),
  family="poisson",PMdata, na.action=na.omit)
summary(M0)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJBA ~ code + PM.2.5Max + (1 + PM.2.5Max | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
## 1237.0   1285.1   -599.5   1199.0      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -5.3127 -1.6853 -0.4296  1.2381 11.3925
##
## Random effects:
## Groups Name          Variance Std.Dev. Corr

```

```

## year (Intercept) 0.2895 0.5381
## PM.2.5Max 15.5559 3.9441 -0.85
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.20631 0.22518 -23.121 < 2e-16 ***
## code2 0.47858 0.09394 5.095 3.50e-07 ***
## code3 0.30512 0.09187 3.321 0.000896 ***
## code4 1.60074 0.10341 15.480 < 2e-16 ***
## code5 0.78989 0.09518 8.299 < 2e-16 ***
## code6 0.05975 0.19169 0.312 0.755270
## code7 0.66924 0.07502 8.921 < 2e-16 ***
## code8 0.47000 0.20385 2.306 0.021134 *
## code9 0.95267 0.06715 14.187 < 2e-16 ***
## code10 -0.06099 0.06399 -0.953 0.340529
## code11 0.27224 0.08906 3.057 0.002237 **
## code12 0.55661 0.06168 9.025 < 2e-16 ***
## code13 0.39447 0.08081 4.881 1.05e-06 ***
## code14 -0.33717 0.08550 -3.944 8.02e-05 ***
## code15 0.17985 0.08438 2.131 0.033055 *
## PM.2.5Max 2.53964 1.56261 1.625 0.104107
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it

check_overdispersion(M0)

## # Overdispersion test
##
## dispersion ratio = 9.121
## Pearson's Chi-Squared = 674.972
## p-value = < 0.001

## Overdispersion detected.

icc(M0)

## # Intraclass Correlation Coefficient
##
## Adjusted ICC: 0.873
## Conditional ICC: 0.403

M0.1=glmer(CountJBA~code+PM.2.5Max+(1|year)+offset(lPop),family="poisson",
PMdata, na.action=na.omit)
summary(M0.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )

```

```

## Formula: CountJBA ~ code + PM.2.5Max + (1 | year) + offset(1Pop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    1308     1351     -637    1274      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -5.2708 -1.6820 -0.4619  1.3026 13.7057
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.08653  0.2942
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -4.821947   0.131140 -36.769  < 2e-16 ***
## code2        0.477517   0.083929   5.690 1.27e-08 ***
## code3        0.216290   0.087836   2.462 0.013800 *
## code4        1.458622   0.099672  14.634 < 2e-16 ***
## code5        0.625756   0.090864   6.887 5.71e-12 ***
## code6       -0.042288   0.190828  -0.222 0.824622
## code7        0.528180   0.070058   7.539 4.73e-14 ***
## code8        0.312602   0.201627   1.550 0.121047
## code9        0.816004   0.063999  12.750 < 2e-16 ***
## code10       -0.101650   0.058714  -1.731 0.083402 .
## code11       0.149579   0.083364   1.794 0.072767 .
## code12       0.416935   0.055691   7.487 7.07e-14 ***
## code13       0.252650   0.074265   3.402 0.000669 ***
## code14      -0.433517   0.084233  -5.147 2.65e-07 ***
## code15      -0.005226   0.080030  -0.065 0.947934
## PM.2.5Max    0.839771   0.296735   2.830 0.004654 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M0.1)

## # Overdispersion test
##
##      dispersion ratio = 10.688
##      Pearson's Chi-Squared = 812.323
##      p-value = < 0.001

## Overdispersion detected.

icc(M0.1)

```

```
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.802
##      Conditional ICC: 0.284

AIC(M0,M0.1)

##      df      AIC
## M0      19 1236.982
## M0.1    17 1307.965

M2=glmer(CountJ451~code+PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),
        family="poisson",PMdata, na.action=na.omit)
summary(M2)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.2.5Max + (1 + PM.2.5Max | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    366.8    414.9   -164.4    328.8      74
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -1.9706 -0.6181 -0.2532  0.4603  3.5409
##
## Random effects:
##  Groups Name      Variance Std.Dev. Corr
##  year  (Intercept) 1.797    1.340
##        PM.2.5Max  1.180    1.086   -1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.071413   0.586223 -13.768 < 2e-16 ***
## code2        0.736841   0.307840   2.394 0.016685 *
## code3        0.172619   0.343916   0.502 0.615722
## code4        1.433574   0.377781   3.795 0.000148 ***
## code5        0.008781   0.425582   0.021 0.983538
## code6        0.760594   0.471048   1.615 0.106379
## code7        0.278226   0.307902   0.904 0.366199
## code8        1.262108   0.481050   2.624 0.008699 **
## code9        1.051006   0.214822   4.892 9.96e-07 ***
## code10       -0.025891   0.208015  -0.124 0.900945
## code11       0.263447   0.290345   0.907 0.364218
## code12       -0.252193   0.248987  -1.013 0.311121
## code13       -0.020118   0.298689  -0.067 0.946300
## code14       -0.934886   0.364421  -2.565 0.010306 *
## code15       -0.102811   0.292423  -0.352 0.725152
## PM.2.5Max    2.730152   1.310537   2.083 0.037230 *
```

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M2)

## # Overdispersion test
##
##     dispersion ratio = 1.235
##   Pearson's Chi-Squared = 91.413
##             p-value = 0.083

## No overdispersion detected.

icc(M2)

## Warning: mu of 0.9 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.658
##   Conditional ICC: 0.559

#основная модель - е в степени 2,46*0,01 мг = 0,066,
#т.е. увеличение на 10 мкг увеличивает на 0,066
#на 50 мкг (как в наших данных) - на 0,33 (при среднегодовых 0,11),
#то есть при сохраняющихся тенденциях нас ждет резкий рост
#неаллергической БА !!!
#Точки 4, 8, 9, отчасти 6 - почему связь?
M2.1=glmer(CountJ451~code+PM.2.5Max+(1|year)+offset(lPop),family="poisson",
           PMdata, na.action=na.omit)
summary(M2.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.2.5Max + (1 | year) + offset(lPop)
##   Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##  363.1    406.2   -164.6    329.1      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9854 -0.6136 -0.2736  0.4332  3.4899
##
## Random effects:
##   Groups Name          Variance Std.Dev.

```

```

## year (Intercept) 1.416 1.19
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
## Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.060168 0.538732 -14.961 < 2e-16 ***
## code2 0.743089 0.308311 2.410 0.01594 *
## code3 0.188456 0.343825 0.548 0.58361
## code4 1.478476 0.371231 3.983 6.82e-05 ***
## code5 0.046162 0.422544 0.109 0.91301
## code6 0.767704 0.471162 1.629 0.10323
## code7 0.297765 0.306598 0.971 0.33145
## code8 1.297964 0.477992 2.715 0.00662 **
## code9 1.068968 0.213058 5.017 5.24e-07 ***
## code10 0.003618 0.202411 0.018 0.98574
## code11 0.292222 0.286691 1.019 0.30807
## code12 -0.200130 0.233993 -0.855 0.39240
## code13 0.013980 0.293653 0.048 0.96203
## code14 -0.927635 0.364328 -2.546 0.01089 *
## code15 -0.061607 0.285451 -0.216 0.82912
## PM.2.5Max 2.460023 1.214980 2.025 0.04289 *
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
## vcov(x) if you need it

check_overdispersion(M2.1)

## # Overdispersion test
##
## dispersion ratio = 1.189
## Pearson's Chi-Squared = 90.355
## p-value = 0.125

## No overdispersion detected.

icc(M2.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
## unreliable.

## # Intraclass Correlation Coefficient
##
## Adjusted ICC: 0.796
## Conditional ICC: 0.654

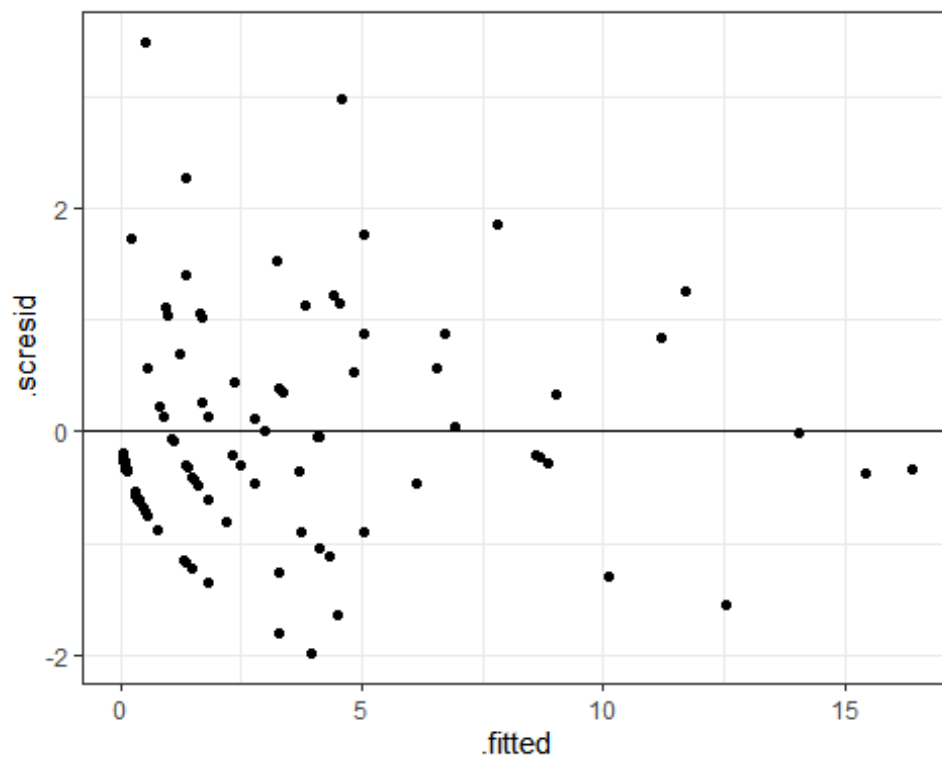
AIC(M2,M2.1)

```

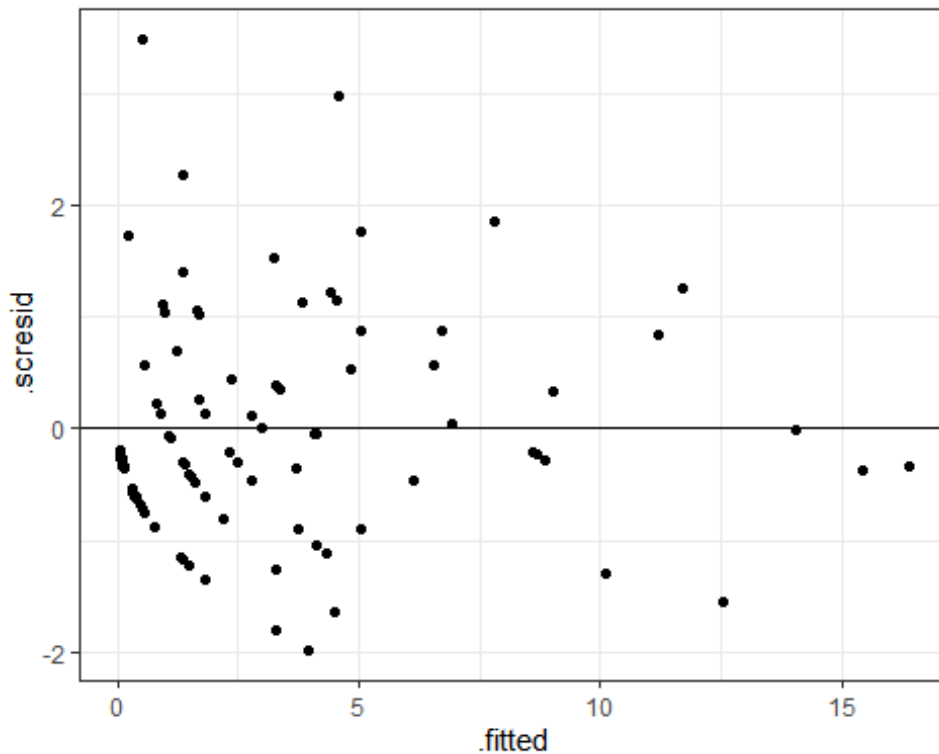
```
##      df      AIC
## M2    19 366.7783
## M2.1  17 363.1376
```

#См ниже анализ остатков для M2.1

#Диагностика модели (анализ остатков) - M2.1:без пропусков/с пропусками
`model_diag(M2.1)`



```
model_diag3(M2.1)
```

```
M3=glmer(CountJ451~code+PM.10Max+(1+PM.10Max|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M3)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.10Max + (1 + PM.10Max | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##  367.1    415.2   -164.5    329.1      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9830 -0.6384 -0.2571  0.5274  3.4488
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year   (Intercept)  2.1369    1.4618
##           PM.10Max    0.9558    0.9776   -1.00
## Number of obs: 93, groups:  year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.2027051  0.6623221 -12.385  < 2e-16 ***
## code2        0.7770778  0.3098918  2.508  0.01216 *
## code3        0.2027829  0.3454846  0.587  0.55724
## code4        1.4504157  0.3791039  3.826  0.00013 ***
```

```

## code5      -0.0008888  0.4228302 -0.002  0.99832
## code6      0.7916529  0.4725111  1.675  0.09385 .
## code7      0.3087972  0.3075830  1.004  0.31540
## code8      1.2924367  0.4824911  2.679  0.00739 **
## code9      1.0829386  0.2138744  5.063  4.12e-07 ***
## code10     -0.0205788  0.2065976 -0.100  0.92066
## code11     0.2353587  0.2888274  0.815  0.41514
## code12     -0.2122875  0.2392708 -0.887  0.37496
## code13     -0.0204601  0.2958436 -0.069  0.94486
## code14     -0.9097220  0.3657316 -2.487  0.01287 *
## code15     -0.0864988  0.2930637 -0.295  0.76788
## PM.10Max    1.8499812  1.0152755  1.822  0.06843 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M3)

## # Overdispersion test
##
##     dispersion ratio = 1.227
##   Pearson's Chi-Squared = 90.797
##           p-value = 0.09

## No overdispersion detected.

icc(M3)

## Warning: mu of 0.9 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.658
##   Conditional ICC: 0.563

#основная модель
M3.1=glmer(CountJ451~code+PM.10Max+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M3.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.10Max + (1 | year) + offset(lPop)
##   Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    363.8    406.8   -164.9    329.8      76

```

```

##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9301 -0.6345 -0.2443  0.5338  3.3148
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.42      1.192
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.08072    0.55520 -14.555 < 2e-16 ***
## code2        0.75366    0.31000  2.431  0.01505 *
## code3        0.19666    0.34588  0.569  0.56964
## code4        1.47789    0.37740  3.916 9.00e-05 ***
## code5        0.01699    0.42253  0.040  0.96792
## code6        0.77416    0.47199  1.640  0.10096
## code7        0.31097    0.30814  1.009  0.31289
## code8        1.31500    0.48183  2.729  0.00635 **
## code9        1.07324    0.21351  5.027 4.99e-07 ***
## code10       0.01308    0.20295  0.064  0.94862
## code11       0.27296    0.28547  0.956  0.33898
## code12      -0.18150    0.23684 -0.766  0.44348
## code13       0.01008    0.29388  0.034  0.97265
## code14      -0.91200    0.36566 -2.494  0.01263 *
## code15      -0.05450    0.29032 -0.188  0.85110
## PM.10Max     1.36513    0.74466  1.833  0.06677 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M3.1)

## # Overdispersion test
##
##      dispersion ratio = 1.174
##      Pearson's Chi-Squared = 89.188
##      p-value = 0.143

## No overdispersion detected.

icc(M3.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##      unreliable.

## # Intraclass Correlation Coefficient
##

```

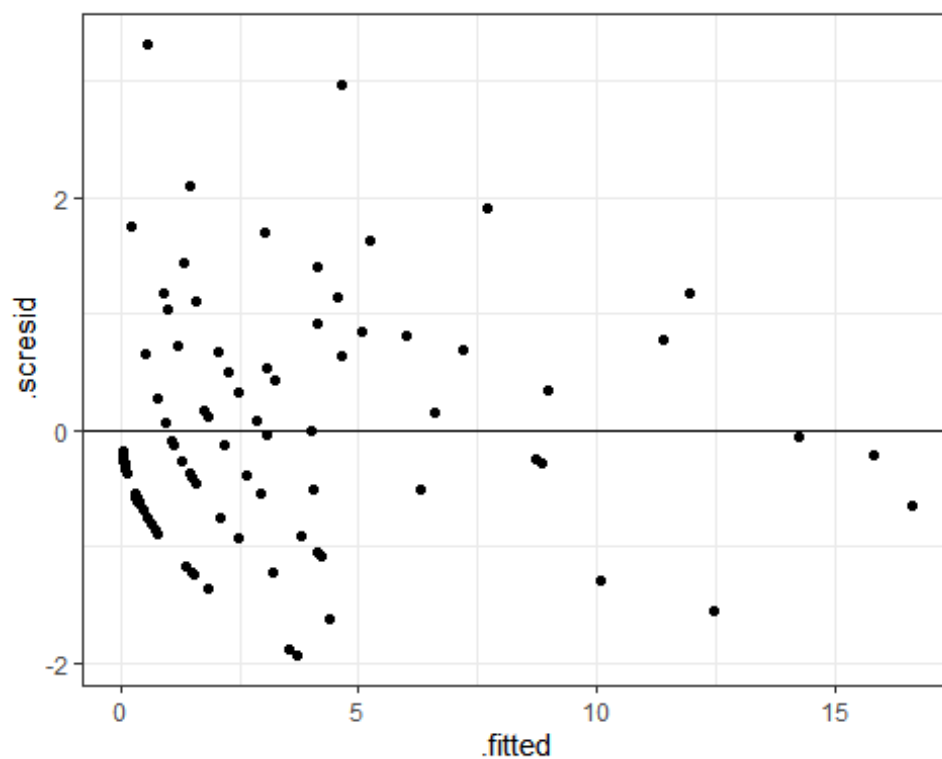
```
## Adjusted ICC: 0.796
## Conditional ICC: 0.658
```

```
AIC(M3,M3.1)
```

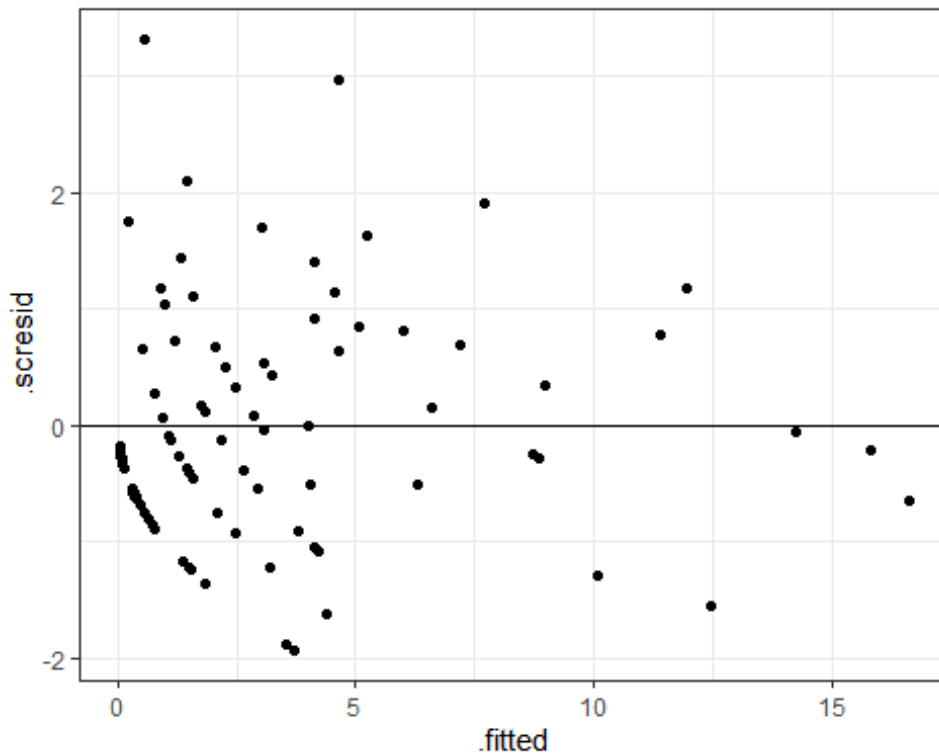
```
##      df      AIC
## M3    19 367.0962
## M3.1  17 363.7869
```

#См ниже анализ остатков для M3.1

#Диагностика модели (анализ остатков) - M3.1:без пропусков/с пропусками
`model_diag(M3.1)`



```
model_diag3(M3.1)
```



```
M4=glmer(CountJ451~code+TSPMax+(1+TSPMax|year)+offset(lPop),
         family="poisson",PMdata, na.action=na.omit)
summary(M4)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TSPMax + (1 + TSPMax | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC  logLik deviance df.resid
##  367.0    415.1  -164.5   329.0      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9330 -0.6516 -0.2238  0.5361  3.3373
##
## Random effects:
##  Groups Name      Variance Std.Dev. Corr
##  year  (Intercept) 3.114    1.765
##        TSPMax     1.575    1.255  -0.92
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.36245    0.81132 -10.307  < 2e-16 ***
## code2        0.84434    0.32109   2.630  0.008549 **
## code3        0.22873    0.34912   0.655  0.512373
## code4        1.42067    0.39826   3.567  0.000361 ***
```

```

## code5      -0.03920    0.43313  -0.091 0.927884
## code6       0.76594    0.47145   1.625 0.104236
## code7       0.22802    0.30393   0.750 0.453115
## code8       1.12561    0.47617   2.364 0.018084 *
## code9       1.07763    0.21849   4.932 8.13e-07 ***
## code10      -0.07254    0.20693  -0.351 0.725914
## code11       0.17665    0.29262   0.604 0.546061
## code12      -0.21374    0.23644  -0.904 0.365985
## code13      -0.04027    0.29412  -0.137 0.891087
## code14      -0.94817    0.36652  -2.587 0.009683 **
## code15      -0.12441    0.30515  -0.408 0.683491
## TSPMax       1.38926    0.87708   1.584 0.113205
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M4)

## # Overdispersion test
##
##     dispersion ratio = 1.155
##     Pearson's Chi-Squared = 85.448
##     p-value = 0.171

## No overdispersion detected.

icc(M4)

## Warning: mu of 1.1 is too close to zero, estimate of random effect variances
may be
##     unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.702
##     Conditional ICC: 0.598

#основная модель
M4.1=glmer(CountJ451~code+TSPMax+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M4.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TSPMax + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    364.7    407.7   -165.3    330.7        76

```

```

##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9131 -0.6463 -0.2244  0.5837  3.4590
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.412      1.188
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.11870    0.59195 -13.715  < 2e-16 ***
## code2        0.76362    0.31330   2.437  0.014796 *
## code3        0.16245    0.34353   0.473  0.636288
## code4        1.48680    0.38956   3.817  0.000135 ***
## code5        0.01691    0.42813   0.039  0.968503
## code6        0.70420    0.46906   1.501  0.133277
## code7        0.23188    0.30412   0.762  0.445777
## code8        1.19233    0.47056   2.534  0.011281 *
## code9        1.03677    0.21114   4.910  9.09e-07 ***
## code10       -0.08947    0.20499  -0.436  0.662490
## code11       0.24718    0.28360   0.872  0.383439
## code12       -0.23940    0.23231  -1.031  0.302763
## code13       -0.07206    0.28904  -0.249  0.803127
## code14       -0.93969    0.36444  -2.578  0.009924 **
## code15       -0.05720    0.29580  -0.193  0.846659
## TSPMax       0.90757    0.58324   1.556  0.119686
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M4.1)

## # Overdispersion test
##
##      dispersion ratio = 1.192
##      Pearson's Chi-Squared = 90.578
##      p-value = 0.121

## No overdispersion detected.

icc(M4.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##      unreliable.

## # Intraclass Correlation Coefficient
##

```

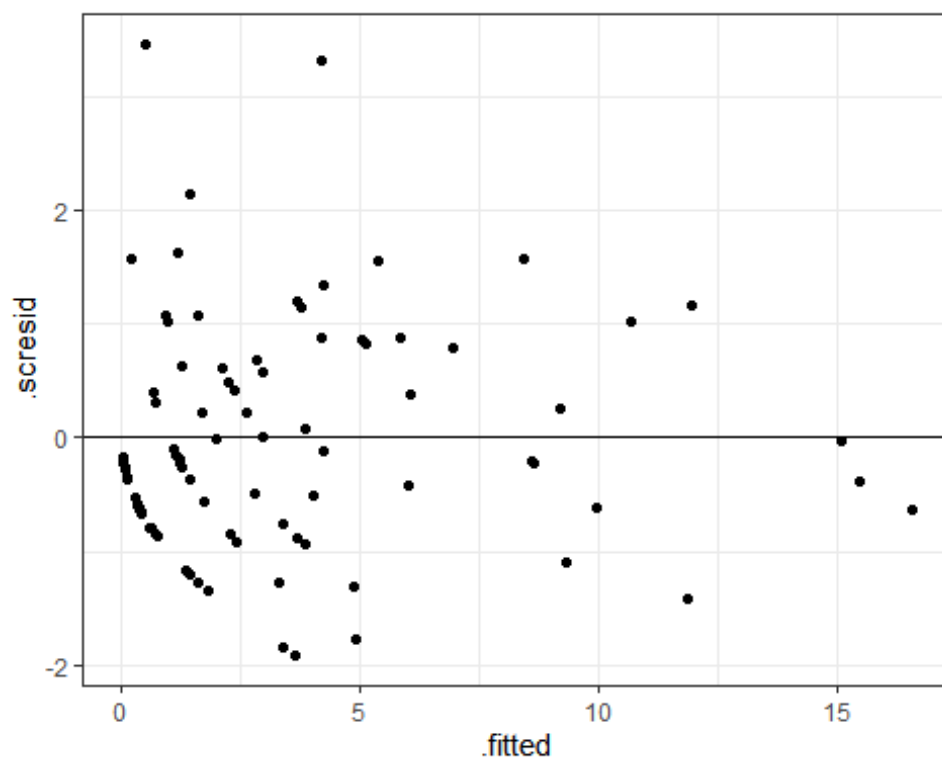
```
## Adjusted ICC: 0.795
## Conditional ICC: 0.655
```

```
AIC(M4,M4.1)
```

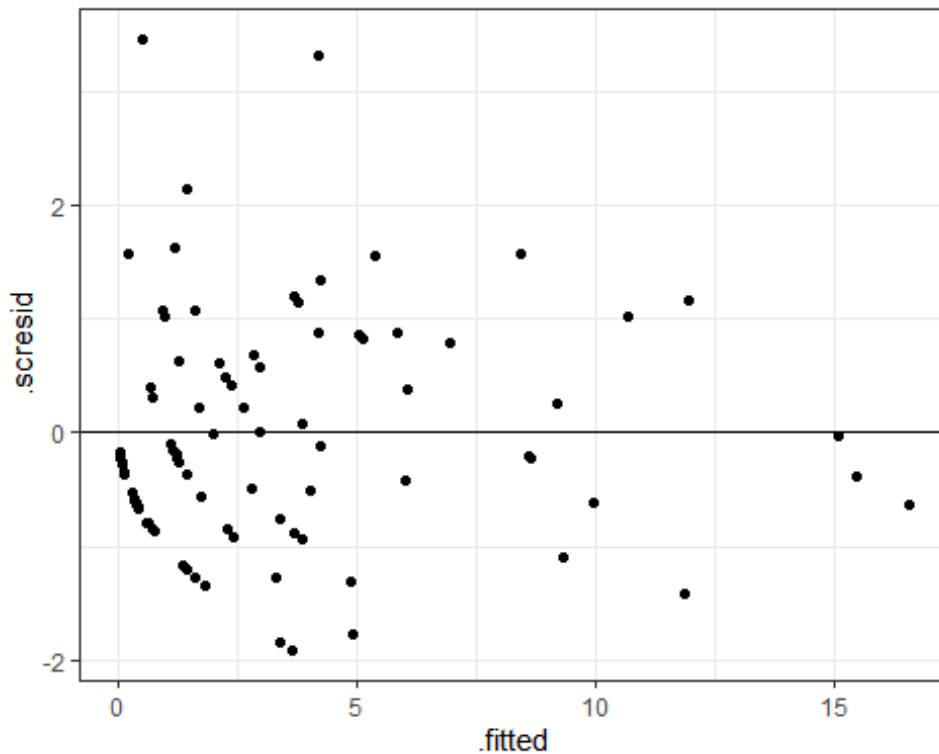
```
##      df      AIC
## M4    19 366.9664
## M4.1  17 364.6747
```

#См ниже анализ остатков для M4.1

#Диагностика модели (анализ остатков) - M4.1:без пропусков/с пропусками
`model_diag(M4.1)`



```
model_diag3(M4.1)
```

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение

```
M5=glmer(CountJ450~code+PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),
```

```
family="poisson",PMdata, na.action=na.omit)
```

```
summary(M5)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
```

```
## Approximation) [glmerMod]
```

```
## Family: poisson ( log )
```

```
## Formula: CountJ450 ~ code + PM.2.5Max + (1 + PM.2.5Max | year) + offset(lPop)
```

```
## Data: PMdata
```

```
##
```

```
##      AIC      BIC   logLik deviance df.resid
```

```
##    749.5    797.6   -355.8    711.5      74
```

```
##
```

```
## Scaled residuals:
```

```
##      Min       1Q   Median       3Q      Max
```

```
## -3.8053 -1.0941 -0.3955  0.7498  6.8594
```

```
##
```

```
## Random effects:
```

```
## Groups Name          Variance Std.Dev. Corr
```

```
## year  (Intercept) 0.1944   0.4409
```

```
##      PM.2.5Max  3.7887   1.9464  0.19
```

```
## Number of obs: 93, groups: year, 7
```

```
##
```

```
## Fixed effects:
```

```
##              Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept) -6.02762    0.22078  -27.301  < 2e-16 ***
```

```
## code2        1.14751    0.12942   8.867  < 2e-16 ***
```

```
## code3        0.31465    0.13865   2.269  0.02324 *
```

```

## code4      1.57333    0.16007    9.829 < 2e-16 ***
## code5      0.84147    0.14088    5.973 2.33e-09 ***
## code6     -0.13443    0.30923   -0.435 0.66377
## code7      0.38211    0.13169    2.902 0.00371 **
## code8      0.37979    0.31195    1.217 0.22342
## code9      0.89128    0.09841    9.057 < 2e-16 ***
## code10     -0.17458    0.09630   -1.813 0.06985 .
## code11     -0.07023    0.14552   -0.483 0.62937
## code12      0.24193    0.10015    2.416 0.01571 *
## code13      0.35105    0.12016    2.922 0.00348 **
## code14     -0.34400    0.12622   -2.725 0.00642 **
## code15      0.25856    0.12013    2.152 0.03137 *
## PM.2.5Max   2.20526    1.03033    2.140 0.03233 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M5)

## # Overdispersion test
##
##     dispersion ratio =    3.864
##   Pearson's Chi-Squared = 285.921
##           p-value = < 0.001

## Overdispersion detected.

icc(M5)

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.854
##   Conditional ICC: 0.529

M5.1=glmer(CountJ450~code+PM.2.5Max+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M5.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.2.5Max + (1 | year) + offset(lPop)
##   Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    760.0    803.1   -363.0    726.0      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.6293 -1.1668 -0.3149  0.8854  7.6561

```

```

##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year  (Intercept) 0.3289   0.5735
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.87482    0.24361 -24.116 < 2e-16 ***
## code2        1.13921    0.11761  9.687 < 2e-16 ***
## code3        0.25098    0.13435  1.868 0.061745 .
## code4        1.45517    0.15612  9.321 < 2e-16 ***
## code5        0.74507    0.13558  5.495 3.9e-08 ***
## code6       -0.17352    0.30847 -0.563 0.573770
## code7        0.33181    0.12639  2.625 0.008658 **
## code8        0.30967    0.30958  1.000 0.317165
## code9        0.83822    0.09594  8.737 < 2e-16 ***
## code10       -0.17688    0.08952 -1.976 0.048162 *
## code11       -0.10571    0.13878 -0.762 0.446237
## code12        0.12092    0.09007  1.343 0.179428
## code13        0.29305    0.11078  2.645 0.008163 **
## code14       -0.38473    0.12501 -3.078 0.002086 **
## code15        0.15660    0.11391  1.375 0.169215
## PM.2.5Max    1.57814    0.47461  3.325 0.000884 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##   vcov(x)           if you need it

check_overdispersion(M5.1)

## # Overdispersion test
##
##      dispersion ratio = 4.220
##   Pearson's Chi-Squared = 320.701
##      p-value = < 0.001

## Overdispersion detected.

icc(M5.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.860
##      Conditional ICC: 0.542

AIC(M5,M5.1)

##      df      AIC
## M5      19 749.5027
## M5.1    17 760.0178

```

```

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M6=glmer(CountJ450~code+PM.10Max+(1+PM.10Max|year)+offset(lPop),
        family="poisson",PMDdata, na.action=na.omit)
summary(M6)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.10Max + (1 + PM.10Max | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    755.8    803.9   -358.9    717.8      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.8386 -1.1366 -0.2332  0.7811  7.2471
##
## Random effects:
##  Groups Name            Variance Std.Dev. Corr
##  year   (Intercept)  0.1846    0.4296
##        PM.10Max    0.7864    0.8868  0.34
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.99777    0.22189 -27.031 < 2e-16 ***
## code2        1.16264    0.13087  8.884 < 2e-16 ***
## code3        0.30824    0.13957  2.208 0.02721 *
## code4        1.53543    0.16007  9.592 < 2e-16 ***
## code5        0.79013    0.13869  5.697 1.22e-08 ***
## code6       -0.14341    0.31000  -0.463 0.64364
## code7        0.38718    0.13222  2.928 0.00341 **
## code8        0.38004    0.31200  1.218 0.22319
## code9        0.90417    0.10681  8.466 < 2e-16 ***
## code10       -0.15566    0.09448  -1.648 0.09943 .
## code11       -0.10109    0.14206  -0.712 0.47673
## code12        0.17681    0.09844  1.796 0.07249 .
## code13        0.31723    0.12060  2.630 0.00853 **
## code14       -0.34383    0.12805  -2.685 0.00725 **
## code15        0.22893    0.12020  1.905 0.05684 .
## PM.10Max     1.09286    0.50946  2.145 0.03194 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M6)

```

```
## # Overdispersion test
##
##      dispersion ratio =    4.035
##      Pearson's Chi-Squared = 298.594
##      p-value = < 0.001

## Overdispersion detected.

icc(M6)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.844
##      Conditional ICC: 0.526

M6.1=glmer(CountJ450~code+PM.10Max+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M6.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.10Max + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    757.6    800.7   -361.8    723.6      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.5144 -1.1085 -0.2549  0.8080  7.8256
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.3223   0.5677
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.98158    0.25047 -23.882 < 2e-16 ***
## code2        1.20689    0.12262  9.842 < 2e-16 ***
## code3        0.29764    0.13683  2.175 0.029609 *
## code4        1.49666    0.15897  9.415 < 2e-16 ***
## code5        0.76595    0.13650  5.611 2.01e-08 ***
## code6       -0.14155    0.30900 -0.458 0.646881
## code7        0.37747    0.12824  2.943 0.003245 **
## code8        0.36075    0.31098  1.160 0.246027
## code9        0.87423    0.09732  8.983 < 2e-16 ***
## code10       -0.16500    0.08955 -1.843 0.065397 .
## code11       -0.11766    0.13844 -0.850 0.395370
## code12        0.15015    0.09112  1.648 0.099378 .
## code13        0.30108    0.11087  2.716 0.006617 **
## code14       -0.35998    0.12575 -2.863 0.004202 **
```

```

## code15      0.19161    0.11621    1.649 0.099205 .
## PM.10Max    1.11867    0.30665    3.648 0.000264 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)      if you need it

check_overdispersion(M6.1)

## # Overdispersion test
##
##      dispersion ratio =    4.242
##      Pearson's Chi-Squared = 322.358
##      p-value = < 0.001

## Overdispersion detected.

icc(M6.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.858
##      Conditional ICC: 0.538

AIC(M6,M6.1)

##      df      AIC
## M6      19 755.7914
## M6.1    17 757.6324

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M7=glmer(CountJ450~code+TSPMax+(1+TSPMax|year)+offset(lPop),
        family="poisson",PMdata, na.action=na.omit)
summary(M7)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + TSPMax + (1 + TSPMax | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    770.1    818.2   -366.0    732.1      74
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -3.3537 -1.1244 -0.2954  0.9201  6.6658
##
## Random effects:
## Groups Name          Variance Std.Dev. Corr
## year  (Intercept) 0.5711    0.7557

```

```

##          TSPMax      0.4797    0.6926    -0.70
## Number of obs: 93, groups:  year, 7
##
## Fixed effects:
##          Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.70357    0.33864 -16.843 < 2e-16 ***
## code2        1.01270    0.14077   7.194 6.28e-13 ***
## code3        0.16642    0.13821   1.204 0.228543
## code4        1.26804    0.16562   7.656 1.91e-14 ***
## code5        0.59942    0.14022   4.275 1.91e-05 ***
## code6       -0.25720    0.30956  -0.831 0.406049
## code7        0.29634    0.12658   2.341 0.019227 *
## code8        0.17057    0.30979   0.551 0.581905
## code9        0.84212    0.09863   8.538 < 2e-16 ***
## code10       -0.19733    0.09481  -2.081 0.037403 *
## code11       -0.18719    0.14199  -1.318 0.187391
## code12        0.10856    0.09189   1.181 0.237467
## code13        0.24740    0.11319   2.186 0.028839 *
## code14       -0.43329    0.12617  -3.434 0.000594 ***
## code15        0.03459    0.12242   0.283 0.777534
## TSPMax       0.26752    0.39873   0.671 0.502277
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M7)

## # Overdispersion test
##
##          dispersion ratio =    4.144
##      Pearson's Chi-Squared = 306.636
##          p-value = < 0.001

## Overdispersion detected.

icc(M7)

## # Intraclass Correlation Coefficient
##
##          Adjusted ICC: 0.858
##          Conditional ICC: 0.559

M7.1=glmer(CountJ450~code+TSPMax+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M7.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + TSPMax + (1 | year) + offset(lPop)

```

```

##      Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    770.9    814.0   -368.5    736.9      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7639 -1.2396 -0.2470  0.8909  7.2094
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 0.3362   0.5798
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.576374   0.268160 -20.795 < 2e-16 ***
## code2        1.034271   0.127840   8.090 5.95e-16 ***
## code3        0.166745   0.135758   1.228 0.219353
## code4        1.265067   0.163777   7.724 1.12e-14 ***
## code5        0.576560   0.137412   4.196 2.72e-05 ***
## code6       -0.243196   0.308146  -0.789 0.429982
## code7        0.282861   0.125607   2.252 0.024325 *
## code8        0.200110   0.308115   0.649 0.516037
## code9        0.795837   0.096284   8.265 < 2e-16 ***
## code10       -0.171208   0.091083  -1.880 0.060149 .
## code11       -0.146851   0.138201  -1.063 0.287967
## code12       0.093004   0.090111   1.032 0.302024
## code13       0.249016   0.109957   2.265 0.023534 *
## code14      -0.430626   0.125575  -3.429 0.000605 ***
## code15       0.035743   0.119671   0.299 0.765187
## TSPMax      -0.003051   0.237087  -0.013 0.989733
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M7.1)

## # Overdispersion test
##
##      dispersion ratio = 4.250
##      Pearson's Chi-Squared = 323.014
##      p-value = < 0.001

## Overdispersion detected.

icc(M7.1)

## # Intraclass Correlation Coefficient
##

```



```

## Adjusted ICC: 0.863
## Conditional ICC: 0.554

AIC(M7,M7.1)

##      df      AIC
## M7    19 770.0692
## M7.1  17 770.9025

M8=glmer(CountJ451~code+PM.2.5Avr+(1+PM.2.5Avr|year)+offset(lPop),
         family="poisson",PMdata, na.action=na.omit)
summary(M8)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.2.5Avr + (1 + PM.2.5Avr | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC  logLik deviance df.resid
##  371.1    419.2  -166.6   333.1      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.1259 -0.7061 -0.2552  0.5930  3.2860
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## year  (Intercept) 1.586    1.260
##      PM.2.5Avr   1.765    1.329   -1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.57320    0.55674 -13.603 < 2e-16 ***
## code2        0.62490    0.32938  1.897  0.05780 .
## code3        0.04680    0.35905  0.130  0.89629
## code4        1.18069    0.40406  2.922  0.00348 **
## code5       -0.23385    0.44939 -0.520  0.60281
## code6        0.64942    0.49071  1.323  0.18569
## code7        0.21118    0.31163  0.678  0.49798
## code8        1.08509    0.50905  2.132  0.03304 *
## code9        0.98776    0.22188  4.452 8.52e-06 ***
## code10       -0.02854    0.20141 -0.142  0.88732
## code11       0.19306    0.28413  0.679  0.49684
## code12       -0.28541    0.24666 -1.157  0.24723
## code13       -0.09854    0.29578 -0.333  0.73902
## code14       -1.01465    0.38193 -2.657  0.00789 **
## code15       -0.27989    0.31072 -0.901  0.36771
## PM.2.5Avr    -0.43926    7.22624 -0.061  0.95153
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M8)

## # Overdispersion test
##
##     dispersion ratio = 1.216
##     Pearson's Chi-Squared = 89.994
##     p-value = 0.1

## No overdispersion detected.

icc(M8)

## Warning: mu of 1.3 is too close to zero, estimate of random effect variances
may be
##     unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.724
##     Conditional ICC: 0.614

#основная модель
M8.1=glmer(CountJ451~code+PM.2.5Avr+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M8.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.2.5Avr + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##  367.1    410.2   -166.6    333.1      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.1316 -0.7140 -0.2543  0.5791  3.3055
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 1.483    1.218
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.56867    0.54107 -13.988 < 2e-16 ***
## code2        0.63247    0.32292  1.959  0.05016 .
## code3        0.05486    0.35256  0.156  0.87636

```

```

## code4      1.19662    0.38092    3.141    0.00168 **
## code5     -0.21869    0.43088   -0.508    0.61177
## code6      0.66058    0.48188    1.371    0.17042
## code7      0.21461    0.31012    0.692    0.48893
## code8      1.10134    0.49031    2.246    0.02469 *
## code9      0.99367    0.21628    4.594 4.34e-06 ***
## code10     -0.02895    0.20137   -0.144    0.88569
## code11      0.19597    0.28306    0.692    0.48874
## code12     -0.27598    0.23357   -1.182    0.23738
## code13     -0.09350    0.29267   -0.319    0.74937
## code14     -1.00555    0.37422   -2.687    0.00721 **
## code15     -0.26709    0.29133   -0.917    0.35925
## PM.2.5Avr  -0.55913    7.14328   -0.078    0.93761
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M8.1)

## # Overdispersion test
##
##     dispersion ratio = 1.184
##   Pearson's Chi-Squared = 90.010
##           p-value = 0.13

## No overdispersion detected.

icc(M8.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.803
##   Conditional ICC: 0.667

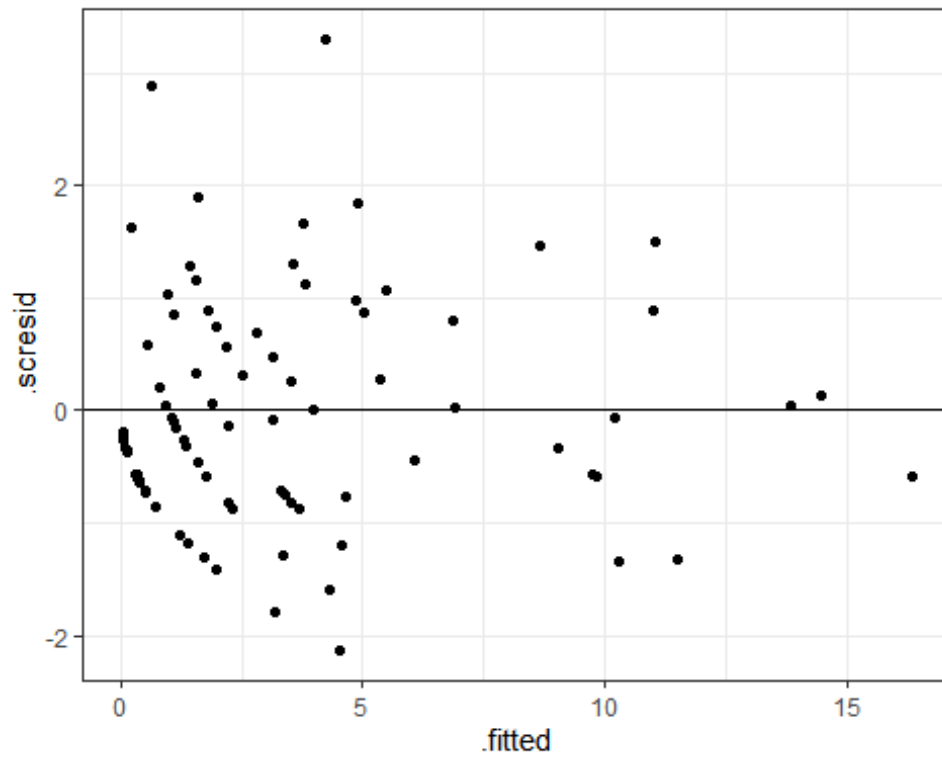
AIC(M8,M8.1)

##      df      AIC
## M8    19 371.1046
## M8.1  17 367.1182

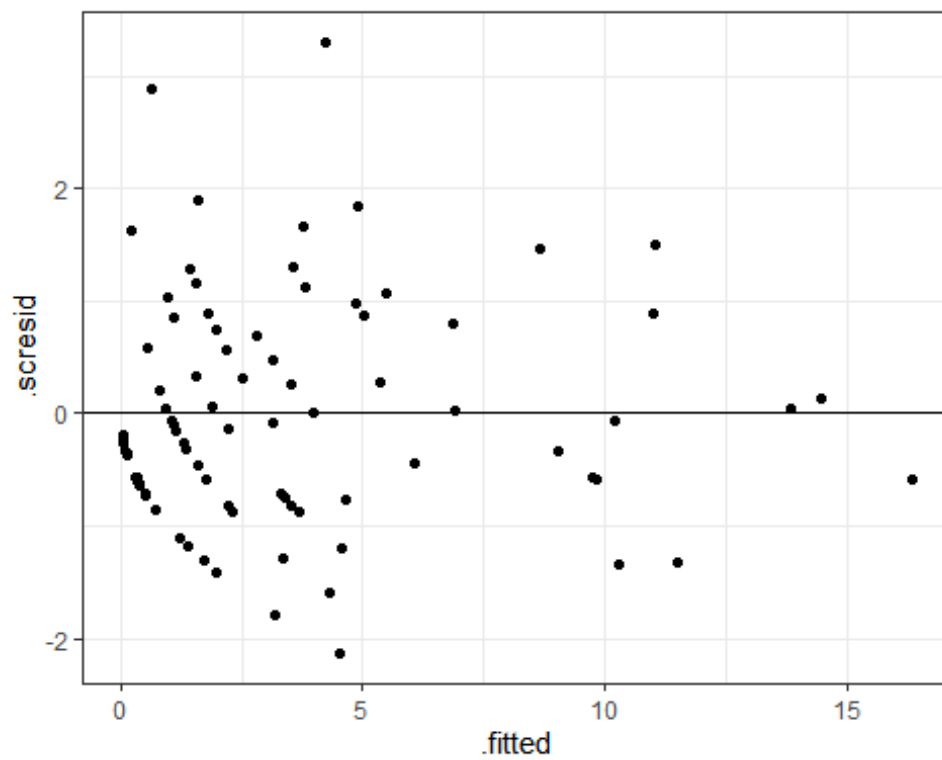
#См ниже анализ остатков для M8.1

#Диагностика модели (анализ остатков) - M8.1:без пропусков/с пропусками
model_diag(M8.1)

```



```
model_diag3(M8.1)
```



```
M9=glmer(CountJ451~code+PM.10Avr+(1+PM.10Avr|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M9)
```

```

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PM.10Avr + (1 + PM.10Avr | year) + offset(1Pop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    368.4    416.6   -165.2    330.4      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0197 -0.6657 -0.2593  0.5144  2.8893
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year  (Intercept)  2.706      1.645
##         PM.10Avr    29.683      5.448   -1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.198576   0.762398  -9.442 < 2e-16 ***
## code2        0.371680   0.362740   1.025  0.30553
## code3       -0.227040   0.393472  -0.577  0.56393
## code4        0.781390   0.444634   1.757  0.07885 .
## code5       -0.559959   0.463210  -1.209  0.22671
## code6        0.478457   0.487470   0.982  0.32634
## code7        0.149523   0.312847   0.478  0.63269
## code8        0.794385   0.511076   1.554  0.12010
## code9        0.902432   0.218383   4.132 3.59e-05 ***
## code10       0.007357   0.203525   0.036  0.97117
## code11       0.081573   0.291227   0.280  0.77940
## code12      -0.393099   0.244553  -1.607  0.10796
## code13      -0.157932   0.294089  -0.537  0.59125
## code14      -1.173818   0.382328  -3.070  0.00214 **
## code15      -0.511497   0.312001  -1.639  0.10113
## PM.10Avr    -3.270380   5.225036  -0.626  0.53138
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M9)

## # Overdispersion test
##
##      dispersion ratio = 1.181
##      Pearson's Chi-Squared = 87.409
##      p-value = 0.137

```

```
## No overdispersion detected.

icc(M9)

## Warning: mu of 1.0 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##       Adjusted ICC: 0.707
##       Conditional ICC: 0.615

#основная модель
M9.1=glmer(CountJ451~code+PM.10Avr+(1|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M9.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula: CountJ451 ~ code + PM.10Avr + (1 | year) + offset(lPop)
##   Data: PMdata
##
##       AIC       BIC    logLik deviance df.resid
##    365.4     408.4   -165.7    331.4        76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0851 -0.6962 -0.2363  0.6123  2.8813
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year   (Intercept) 1.634    1.278
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.07326    0.64067 -11.040 < 2e-16 ***
## code2        0.38368    0.35933  1.068  0.28563
## code3       -0.20143    0.39078 -0.515  0.60623
## code4        0.85876    0.43494  1.974  0.04833 *
## code5       -0.50007    0.45837 -1.091  0.27529
## code6        0.48584    0.48784  0.996  0.31930
## code7        0.13143    0.31232  0.421  0.67390
## code8        0.85002    0.50721  1.676  0.09376 .
## code9        0.91620    0.21803  4.202 2.64e-05 ***
## code10      -0.01488    0.20192 -0.074  0.94124
## code11       0.11764    0.28855  0.408  0.68349
## code12      -0.37751    0.24340 -1.551  0.12091
## code13      -0.15858    0.29374 -0.540  0.58930
## code14      -1.15614    0.38141 -3.031  0.00244 **
## code15      -0.46070    0.30628 -1.504  0.13253
```

```

## PM.10Avr      -5.65532      4.25756  -1.328  0.18408
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M9.1)

## # Overdispersion test
##
##      dispersion ratio =  1.142
##      Pearson's Chi-Squared = 86.825
##      p-value =  0.186

## No overdispersion detected.

icc(M9.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##      unreliable.

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.818
##      Conditional ICC: 0.685

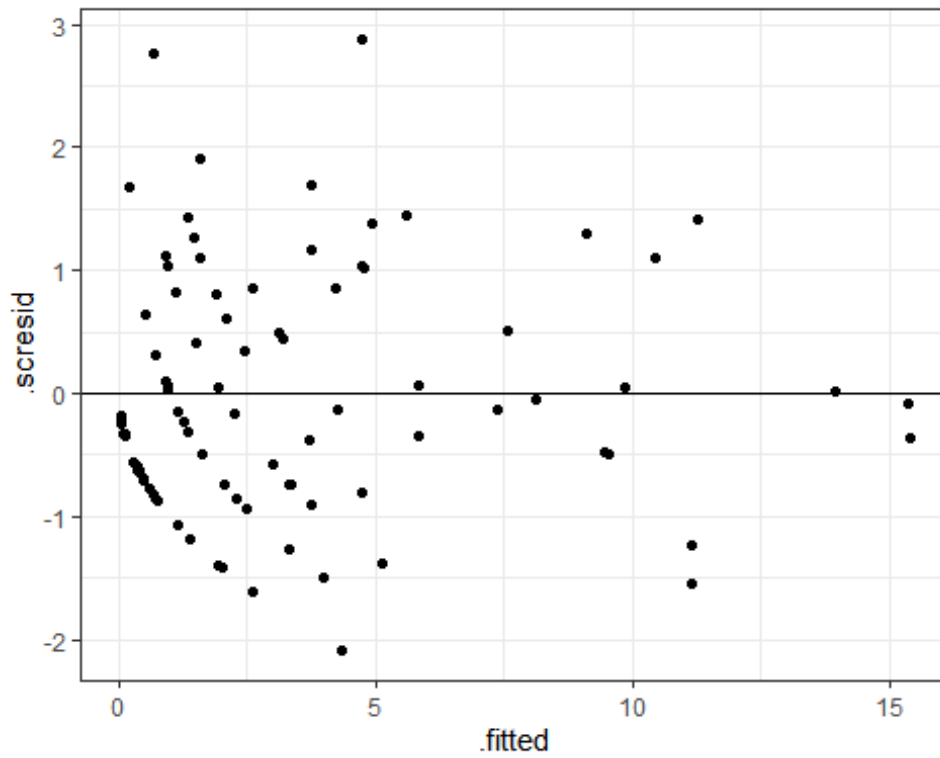
AIC(M9,M9.1)

##      df      AIC
## M9      19 368.4354
## M9.1    17 365.3748

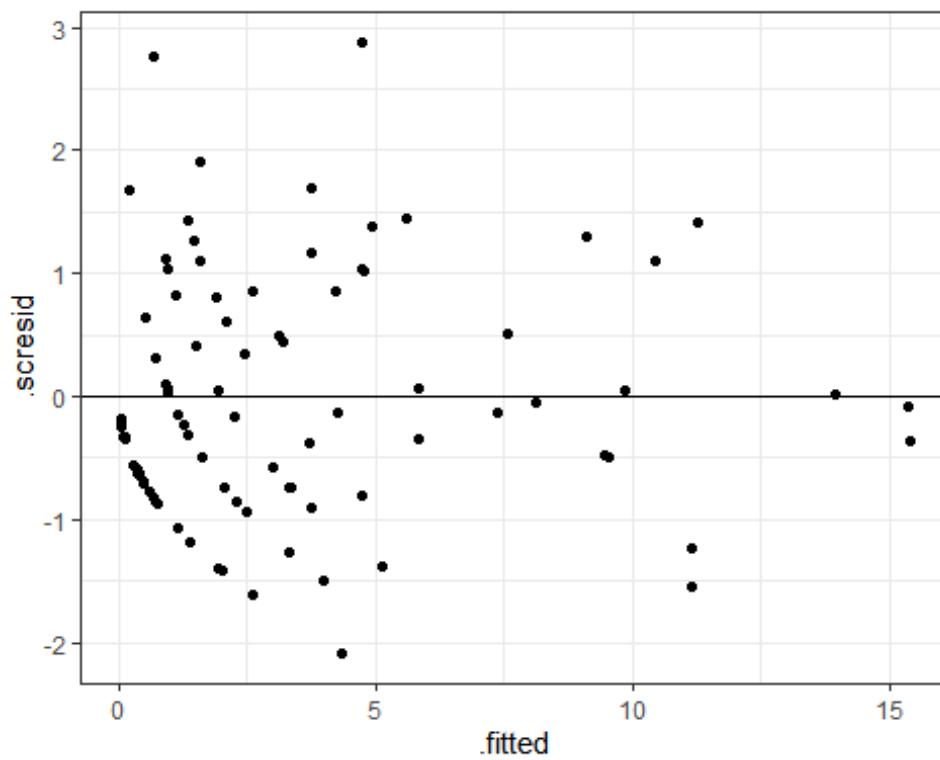
#См ниже анализ остатков для M9.1

#Диагностика модели (анализ остатков) - M9.1:без пропусков/с пропусками
model_diag(M9.1)

```



```
model_diag3(M9.1)
```



```
M10=glmer(CountJ451~code+TSPAвр+(1+TSPAвр|year)+offset(lPop),
           family="poisson",PMdata, na.action=na.omit)
summary(M10)
```



```

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TSPAver + (1 + TSPAver | year) + offset(1Pop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    367.9    416.0   -165.0    329.9      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9960 -0.6606 -0.2482  0.4885  2.9820
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year  (Intercept)    3.596     1.896
##         TSPAver       24.044     4.904    -1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.34637    0.88759  -8.277 < 2e-16 ***
## code2        0.45387    0.36333   1.249  0.21159
## code3       -0.15167    0.38701  -0.392  0.69514
## code4        0.89810    0.41812   2.148  0.03172 *
## code5       -0.46133    0.44396  -1.039  0.29874
## code6        0.57564    0.48012   1.199  0.23054
## code7        0.21131    0.30705   0.688  0.49133
## code8        0.90342    0.49283   1.833  0.06678 .
## code9        0.92810    0.21648   4.287 1.81e-05 ***
## code10       0.06015    0.20756   0.290  0.77199
## code11       0.11621    0.28671   0.405  0.68525
## code12      -0.38945    0.24670  -1.579  0.11442
## code13      -0.11847    0.29204  -0.406  0.68498
## code14      -1.12915    0.37929  -2.977  0.00291 **
## code15      -0.47656    0.30898  -1.542  0.12298
## TSPAver     -0.67061    3.75212  -0.179  0.85815
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M10)

## # Overdispersion test
##
##      dispersion ratio = 1.188
##      Pearson's Chi-Squared = 87.898
##      p-value = 0.129

```

```

## No overdispersion detected.

icc(M10)

## boundary (singular) fit: see ?isSingular

## Warning: mu of 0.8 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##       Adjusted ICC: 0.676
##       Conditional ICC: 0.588

#основная модель
M10.1=glmer(CountJ451~code+TSPAвр+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M10.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula: CountJ451 ~ code + TSPAвр + (1 | year) + offset(lPop)
##   Data: PMdata
##
##           AIC          BIC    logLik deviance df.resid
##        366.0         409.1    -166.0     332.0         76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.1209 -0.6893 -0.2415  0.6079  3.0049
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.684      1.298
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.09168    0.69627 -10.185 < 2e-16 ***
## code2        0.43224    0.36105   1.197  0.23123
## code3       -0.13539    0.38473  -0.352  0.72491
## code4        0.96771    0.41386   2.338  0.01938 *
## code5       -0.39268    0.43913  -0.894  0.37121
## code6        0.55435    0.48049   1.154  0.24862
## code7        0.18002    0.30727   0.586  0.55798
## code8        0.95756    0.49023   1.953  0.05079 .
## code9        0.93884    0.21663   4.334 1.47e-05 ***
## code10       0.01756    0.20608   0.085  0.93211
## code11       0.15492    0.28515   0.543  0.58693
## code12      -0.36225    0.24560  -1.475  0.14022
## code13      -0.13262    0.29182  -0.454  0.64950
## code14      -1.11472    0.37888  -2.942  0.00326 **

```

```

## code15      -0.41073    0.30265  -1.357  0.17475
## TSPAver     -3.11129    2.91766  -1.066  0.28626
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M10.1)

## # Overdispersion test
##
##      dispersion ratio = 1.154
##      Pearson's Chi-Squared = 87.674
##      p-value = 0.17

## No overdispersion detected.

icc(M10.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##      unreliable.

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.822
##      Conditional ICC: 0.690

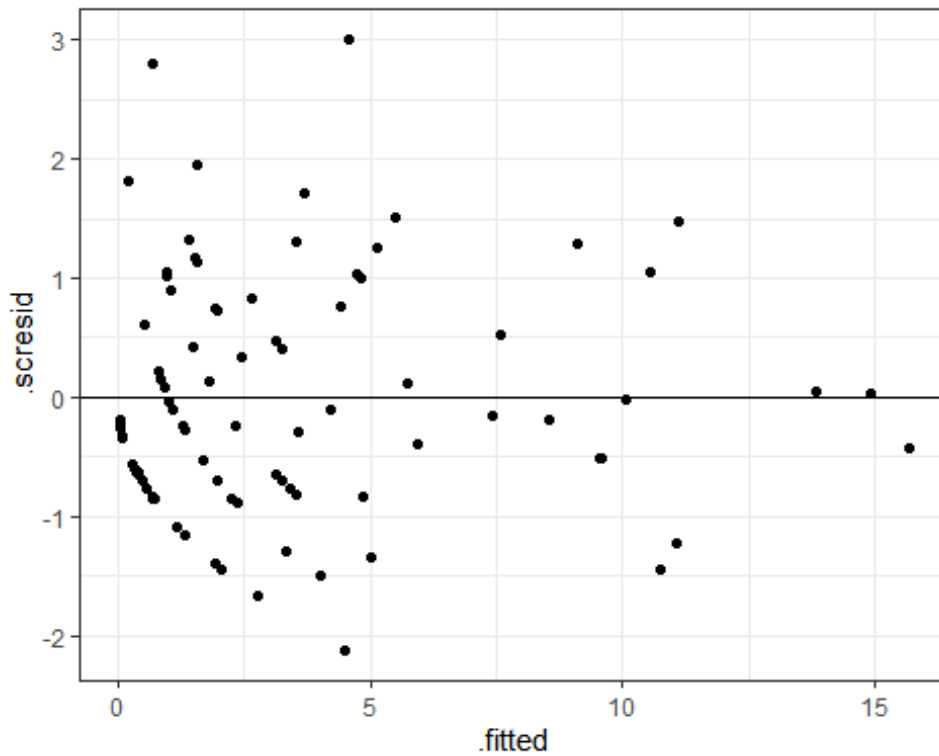
AIC(M10,M10.1)

##      df      AIC
## M10    19 367.9301
## M10.1  17 366.0068

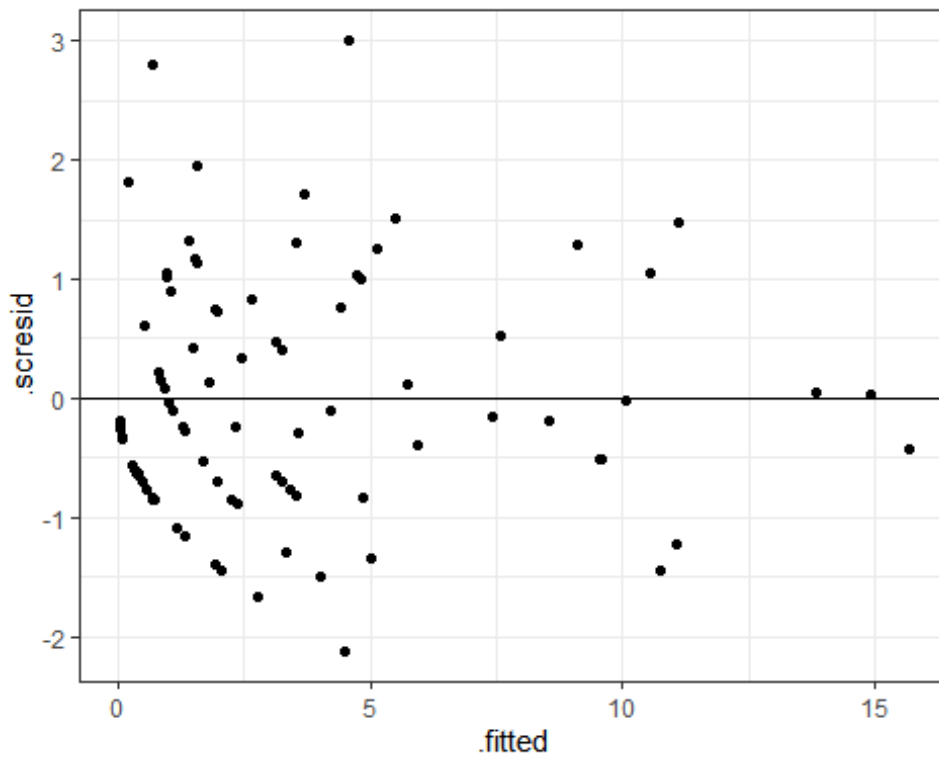
#См ниже анализ остатков для M10.1

#Диагностика модели (анализ остатков) - M10.1:без пропусков/с пропусками
model_diag(M10.1)

```



```
model_diag3(M10.1)
```



#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение

```
M11=glmer(CountJ450~code+PM.2.5Avr+(1+PM.2.5Avr|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M11)
```

```

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.2.5Avr + (1 + PM.2.5Avr | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    764.5    812.6   -363.2    726.5      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.0137 -1.1153 -0.2443  0.8369  7.0277
##
## Random effects:
## Groups Name             Variance Std.Dev. Corr
## year  (Intercept)    0.1425  0.3775
##      PM.2.5Avr    128.4401 11.3331  0.55
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.59332    0.19151 -29.206 < 2e-16 ***
## code2        1.03155    0.13557  7.609 2.76e-14 ***
## code3        0.26428    0.14580  1.813 0.06990 .
## code4        1.38340    0.16923  8.175 2.97e-16 ***
## code5        0.68191    0.15044  4.533 5.83e-06 ***
## code6       -0.17901    0.31372 -0.571 0.56825
## code7        0.30670    0.13746  2.231 0.02567 *
## code8        0.28319    0.31822  0.890 0.37352
## code9        0.83386    0.10159  8.208 2.25e-16 ***
## code10       -0.23647    0.09594 -2.465 0.01371 *
## code11       -0.15128    0.14065 -1.076 0.28210
## code12        0.17305    0.09982  1.734 0.08297 .
## code13        0.20391    0.11657  1.749 0.08025 .
## code14       -0.35390    0.13422 -2.637 0.00837 **
## code15        0.11983    0.12606  0.951 0.34183
## PM.2.5Avr    1.82870    5.45348  0.335 0.73738
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M11)

## # Overdispersion test
##
##      dispersion ratio = 4.047
##      Pearson's Chi-Squared = 299.458
##      p-value = < 0.001

```

```
## Overdispersion detected.

icc(M11)

## boundary (singular) fit: see ?isSingular

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.805
##      Conditional ICC: 0.509

M11.1=glmer(CountJ450~code+PM.2.5Avr+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M11.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.2.5Avr + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    770.6    813.6   -368.3    736.6      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7717 -1.2607 -0.1735  0.8606  7.1762
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.3268   0.5717
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.53382    0.23933 -23.122 < 2e-16 ***
## code2        1.01040    0.12197  8.284 < 2e-16 ***
## code3        0.14556    0.13751  1.059 0.289796
## code4        1.23443    0.15630  7.898 2.84e-15 ***
## code5        0.54707    0.13719  3.988 6.67e-05 ***
## code6       -0.26541    0.31039 -0.855 0.392499
## code7        0.26511    0.12971  2.044 0.040969 *
## code8        0.17285    0.31171  0.555 0.579228
## code9        0.78555    0.09686  8.110 5.06e-16 ***
## code10       -0.17197    0.08946 -1.922 0.054570 .
## code11       -0.15080    0.13833 -1.090 0.275635
## code12        0.08821    0.09012  0.979 0.327678
## code13        0.24172    0.11069  2.184 0.028976 *
## code14       -0.44848    0.12846 -3.491 0.000481 ***
## code15        0.01339    0.11536  0.116 0.907599
## PM.2.5Avr    -1.42024    2.57289 -0.552 0.580947
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M11.1)

## # Overdispersion test
##
##     dispersion ratio =    4.245
##   Pearson's Chi-Squared = 322.641
##           p-value = < 0.001

## Overdispersion detected.

icc(M11.1)

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.859
##   Conditional ICC: 0.547

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M12=glmer(CountJ450~code+PM.10Avr+(1+PM.10Avr|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M12)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.10Avr + (1 + PM.10Avr | year) + offset(lPop)
##   Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    760.8    809.0   -361.4    722.8      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.821 -1.086 -0.337  0.804  6.862
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year   (Intercept)    0.3508   0.5923
##         PM.10Avr      23.6394   4.8620   -0.31
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.36228    0.28947 -18.525 < 2e-16 ***
## code2        0.91735    0.14839  6.182 6.33e-10 ***
## code3        0.19257    0.15968  1.206 0.227832
## code4        1.16741    0.18248  6.397 1.58e-10 ***
## code5        0.49973    0.15635  3.196 0.001393 **
## code6       -0.28074    0.31445 -0.893 0.371956
```

```

## code7      0.23522    0.13991    1.681 0.092735 .
## code8      0.11896    0.31909    0.373 0.709288
## code9      0.78674    0.10141    7.758 8.63e-15 ***
## code10     -0.20074    0.09406   -2.134 0.032831 *
## code11     -0.18319    0.14233   -1.287 0.198080
## code12      0.11224    0.09941    1.129 0.258888
## code13      0.23901    0.11406    2.095 0.036133 *
## code14     -0.46446    0.13454   -3.452 0.000556 ***
## code15     -0.02988    0.12668   -0.236 0.813559
## PM.10Avr   -2.67786    2.67219   -1.002 0.316284
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)           if you need it

check_overdispersion(M12)

## # Overdispersion test
##
##     dispersion ratio =    3.934
##   Pearson's Chi-Squared = 291.143
##           p-value = < 0.001

## Overdispersion detected.

icc(M12)

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.807
##   Conditional ICC: 0.528

M12.1=glmer(CountJ450~code+PM.10Avr+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M12.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + PM.10Avr + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##   770.1    813.1   -368.0    736.1      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7528 -1.2071 -0.2415  0.8079  7.2111
##
## Random effects:
## Groups Name          Variance Std.Dev.

```



```

## year (Intercept) 0.3479 0.5899
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##      Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.43299    0.28223 -19.250 < 2e-16 ***
## code2        0.96358    0.13828  6.968 3.21e-12 ***
## code3        0.09161    0.15607  0.587 0.557204
## code4        1.16864    0.18110  6.453 1.10e-10 ***
## code5        0.49594    0.15460  3.208 0.001337 **
## code6       -0.30020    0.31415 -0.956 0.339290
## code7        0.24217    0.13358  1.813 0.069835 .
## code8        0.12732    0.31810  0.400 0.688962
## code9        0.77236    0.09851  7.840 4.49e-15 ***
## code10       -0.17190    0.08946 -1.921 0.054670 .
## code11       -0.16615    0.13979 -1.189 0.234595
## code12        0.05946    0.09697  0.613 0.539774
## code13        0.23218    0.11149  2.083 0.037289 *
## code14       -0.47279    0.13276 -3.561 0.000369 ***
## code15       -0.01992    0.12424 -0.160 0.872622
## PM.10Avr     -1.54512    1.71372 -0.902 0.367259
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M12.1)

## # Overdispersion test
##
##      dispersion ratio = 4.245
##      Pearson's Chi-Squared = 322.636
##      p-value = < 0.001

## Overdispersion detected.

icc(M12.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.867
##      Conditional ICC: 0.563

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M13=glmer(CountJ450~code+TSPAvr+(1+TSPAvr|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M13)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )

```

```

## Formula: CountJ450 ~ code + TSPAver + (1 + TSPAver | year) + offset(1Pop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    757.4    805.5   -359.7    719.4      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7767 -1.0936 -0.4052  0.6848  5.8494
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept)  0.8895   0.9431
##         TSPAver      24.9827  4.9983   -0.85
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.49896    0.41514 -13.246 < 2e-16 ***
## code2        0.99190    0.15762  6.293 3.11e-10 ***
## code3        0.24186    0.15627  1.548 0.121686
## code4        1.21590    0.17328  7.017 2.27e-12 ***
## code5        0.54550    0.14593  3.738 0.000185 ***
## code6       -0.26952    0.31227  -0.863 0.388078
## code7        0.28263    0.13699  2.063 0.039097 *
## code8        0.14876    0.31410  0.474 0.635791
## code9        0.81602    0.10022  8.142 3.89e-16 ***
## code10       -0.22642    0.09588  -2.362 0.018198 *
## code11       -0.18630    0.14105  -1.321 0.186566
## code12        0.14339    0.09951  1.441 0.149590
## code13        0.25006    0.11322  2.209 0.027203 *
## code14       -0.44192    0.13392  -3.300 0.000967 ***
## code15       -0.01305    0.12379  -0.105 0.916015
## TSPAver      -0.28020    2.29843  -0.122 0.902971
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M13)

## # Overdispersion test
##
##      dispersion ratio = 3.824
##      Pearson's Chi-Squared = 282.988
##      p-value = < 0.001

## Overdispersion detected.

icc(M12)

```

```
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.807
##      Conditional ICC: 0.528

M13.1=glmer(CountJ450~code+TSPAвр+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M13.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + TSPAвр + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##    770.7    813.7   -368.3    736.7      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.7546 -1.2380 -0.2393  0.8481  7.3009
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.3464   0.5886
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.487939   0.298004 -18.416 < 2e-16 ***
## code2        0.996517   0.138866   7.176 7.17e-13 ***
## code3        0.131009   0.151701   0.864 0.387809
## code4        1.222767   0.171035   7.149 8.73e-13 ***
## code5        0.544776   0.142807   3.815 0.000136 ***
## code6       -0.266437   0.311570  -0.855 0.392471
## code7        0.266539   0.130196   2.047 0.040637 *
## code8        0.173273   0.312811   0.554 0.579632
## code9        0.785510   0.097478   8.058 7.74e-16 ***
## code10       -0.165526   0.090292  -1.833 0.066767 .
## code11       -0.152452   0.138639  -1.100 0.271492
## code12        0.076029   0.096408   0.789 0.430338
## code13        0.242576   0.110726   2.191 0.028468 *
## code14       -0.450441   0.131037  -3.438 0.000587 ***
## code15        0.009734   0.121030   0.080 0.935900
## TSPAвр       -0.548706   1.141308  -0.481 0.630680
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)      if you need it
```

```

check_overdispersion(M13.1)

## # Overdispersion test
##
##      dispersion ratio =    4.255
##      Pearson's Chi-Squared = 323.344
##      p-value = < 0.001

## Overdispersion detected.

icc(M13.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.866
##      Conditional ICC: 0.561

M14=glmer(CountJ451~code+TBPLogAvr+(1+TBLogAvr|year)+offset(lPop),
          family="poisson", PMdata, na.action=na.omit)

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
:
## Model failed to converge with max|grad| = 0.00299709 (tol = 0.002, component
1)

summary(M14)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TBPLogAvr + (1 + TBLogAvr | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    399.4    448.5   -180.7    361.4      79
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0196 -0.6761 -0.3236  0.6468  2.8088
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year  (Intercept)      2.539    1.593
##         TBLogAvr      32652.668 180.700  -1.00
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.61622    0.63065 -12.077 < 2e-16 ***
## code2        0.10247    0.26609  0.385  0.70018
## code3        0.06739    0.27950  0.241  0.80948
## code4        1.04804    0.36862  2.843  0.00447 **
## code5       -0.33932    0.41779 -0.812  0.41669
## code6        0.60218    0.47372  1.271  0.20367

```

```

## code7      -0.10758    0.23553  -0.457  0.64785
## code8      0.98431    0.47955   2.053  0.04011 *
## code9      0.96785    0.21446   4.513  6.39e-06 ***
## code10     -0.01915    0.20204  -0.095  0.92449
## code11     0.26245    0.28547   0.919  0.35792
## code12     -0.33468    0.24182  -1.384  0.16636
## code13     -0.12331    0.29037  -0.425  0.67107
## code14     -1.07460    0.36722  -2.926  0.00343 **
## code15     -0.35241    0.27840  -1.266  0.20557
## TBPLogAvr   2.25439   32.70748   0.069  0.94505
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## Model failed to converge with max|grad| = 0.00299709 (tol = 0.002, component
1)

check_overdispersion(M14)

## # Overdispersion test
##
##      dispersion ratio =  1.242
##      Pearson's Chi-Squared = 98.129
##      p-value =  0.071

## No overdispersion detected.

OverDisp2(M14)

## numeric(0)

icc(M14)

## Warning: Random slopes not present as fixed effects. This artificially inflates the
## conditional random effect variances.
## Solution: Respecify fixed structure!

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
: Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

## Warning: mu of 1.0 is too close to zero, estimate of random effect variances
may be
## unreliable.

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.786
##      Conditional ICC: 0.711

```

#основная модель

```
M14.1=glmer(CountJ451~code+TBPLogAvr+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M14.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TBPLogAvr + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##  399.1    443.0   -182.5    365.1      81
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0084 -0.6736 -0.2818  0.6419  3.2495
##
## Random effects:
##  Groups Name      Variance Std.Dev.
##  year  (Intercept) 1.348    1.161
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.58214    0.51861 -14.620 < 2e-16 ***
## code2        0.15338    0.27132  0.565 0.571868
## code3        0.13755    0.28365  0.485 0.627720
## code4        1.24223    0.37662  3.298 0.000973 ***
## code5       -0.17676    0.42483 -0.416 0.677355
## code6        0.68932    0.47684  1.446 0.148288
## code7       -0.04837    0.24078 -0.201 0.840772
## code8        1.13998    0.48383  2.356 0.018465 *
## code9        1.00931    0.21577  4.678 2.9e-06 ***
## code10       -0.02894    0.20143 -0.144 0.885760
## code11       0.29965    0.28511  1.051 0.293258
## code12      -0.27330    0.24139 -1.132 0.257542
## code13      -0.08397    0.28990 -0.290 0.772081
## code14      -0.98394    0.36808 -2.673 0.007514 **
## code15      -0.22966    0.27912 -0.823 0.410634
## TBPLogAvr    6.23108    27.29715  0.228 0.819438
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M14.1)

## # Overdispersion test
##
```

```
##      dispersion ratio = 1.249
##      Pearson's Chi-Squared = 101.184
##      p-value = 0.064

## No overdispersion detected.

OverDisp1(M14.1)

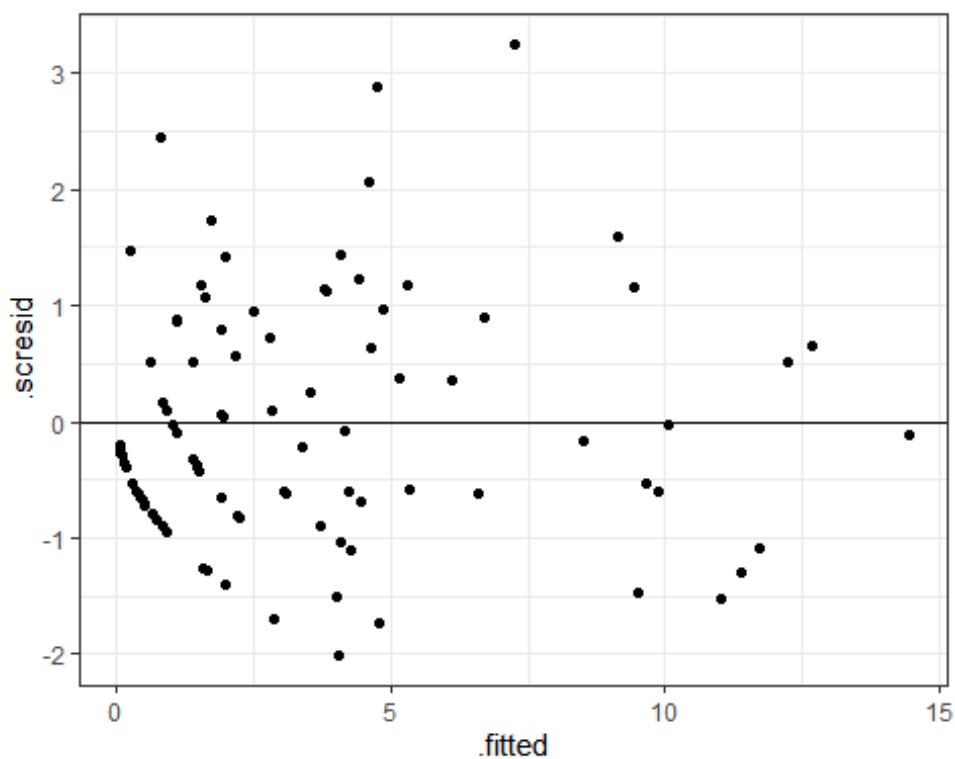
## numeric(0)

icc(M14.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
## unreliable.

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.787
##      Conditional ICC: 0.653

#См ниже анализ остатков для M14.1
model_diag3(M14.1)
```



```
M15=glmer(CountJ451~code+PLogAvr+(1+PLogAvr|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M15)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
```

```

## Formula: CountJ451 ~ code + PLogAvr + (1 + PLogAvr | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    400.1    449.3   -181.1    362.1      79
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0279 -0.6817 -0.3144  0.6893  2.8161
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept)    2.291   1.513
##         PLogAvr      15508.933 124.535  -1.00
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.55602    0.63537 -11.892 < 2e-16 ***
## code2        0.11602    0.26775   0.433  0.66480
## code3        0.07817    0.27987   0.279  0.78002
## code4        1.06180    0.37506   2.831  0.00464 **
## code5       -0.33145    0.42257  -0.784  0.43283
## code6        0.60082    0.47518   1.264  0.20609
## code7       -0.10761    0.23831  -0.452  0.65157
## code8        0.98812    0.48437   2.040  0.04135 *
## code9        0.97346    0.21596   4.508 6.56e-06 ***
## code10       -0.02108    0.20202  -0.104  0.91690
## code11       0.26869    0.28543   0.941  0.34653
## code12      -0.33311    0.24270  -1.373  0.16989
## code13      -0.12287    0.29067  -0.423  0.67251
## code14      -1.07411    0.36896  -2.911  0.00360 **
## code15      -0.34578    0.28198  -1.226  0.22010
## PLogAvr      1.32057   56.62871   0.023  0.98140
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M15)

## # Overdispersion test
##
##      dispersion ratio = 1.247
##      Pearson's Chi-Squared = 98.528
##      p-value = 0.068

## No overdispersion detected.

OverDisp2(M15)

```



```

## numeric(0)

icc(M15)

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
: Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

## Warning: mu of 1.2 is too close to zero, estimate of random effect variances
may be
## unreliable.

## # Intraclass Correlation Coefficient
##
## Adjusted ICC: 0.705
## Conditional ICC: 0.606

#основная модель
M15.1=glmer(CountJ451~code+PLogAvr+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M15.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PLogAvr + (1 | year) + offset(lPop)
## Data: PMdata
##
## AIC      BIC    logLik deviance df.resid
## 399.0    442.9   -182.5   365.0     81
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0169 -0.6752 -0.2821  0.6528  3.2450
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 1.352    1.163
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.60199    0.51148 -14.863 < 2e-16 ***
## code2        0.16387    0.27089  0.605 0.545214
## code3        0.14556    0.28185  0.516 0.605543
## code4        1.25739    0.37339  3.368 0.000758 ***
## code5       -0.16240    0.42290 -0.384 0.700963
## code6        0.69873    0.47607  1.468 0.142191
## code7       -0.03919    0.24089 -0.163 0.870762
## code8        1.15435    0.48325  2.389 0.016906 *
## code9        1.01616    0.21628  4.698 2.62e-06 ***
## code10       -0.02861    0.20143 -0.142 0.887042
## code11        0.30300    0.28487  1.064 0.287492
## code12       -0.27011    0.24105 -1.121 0.262480

```

```

## code13      -0.08158    0.28976  -0.282  0.778293
## code14      -0.97711    0.36765  -2.658  0.007867 **
## code15      -0.22081    0.27823  -0.794  0.427402
## PLogAvr     15.51300    43.91897   0.353  0.723925
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M15.1)

## # Overdispersion test
##
##      dispersion ratio =    1.248
##      Pearson's Chi-Squared = 101.070
##      p-value =    0.065

## No overdispersion detected.

OverDisp1(M15.1)

## numeric(0)

icc(M15.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##      unreliable.

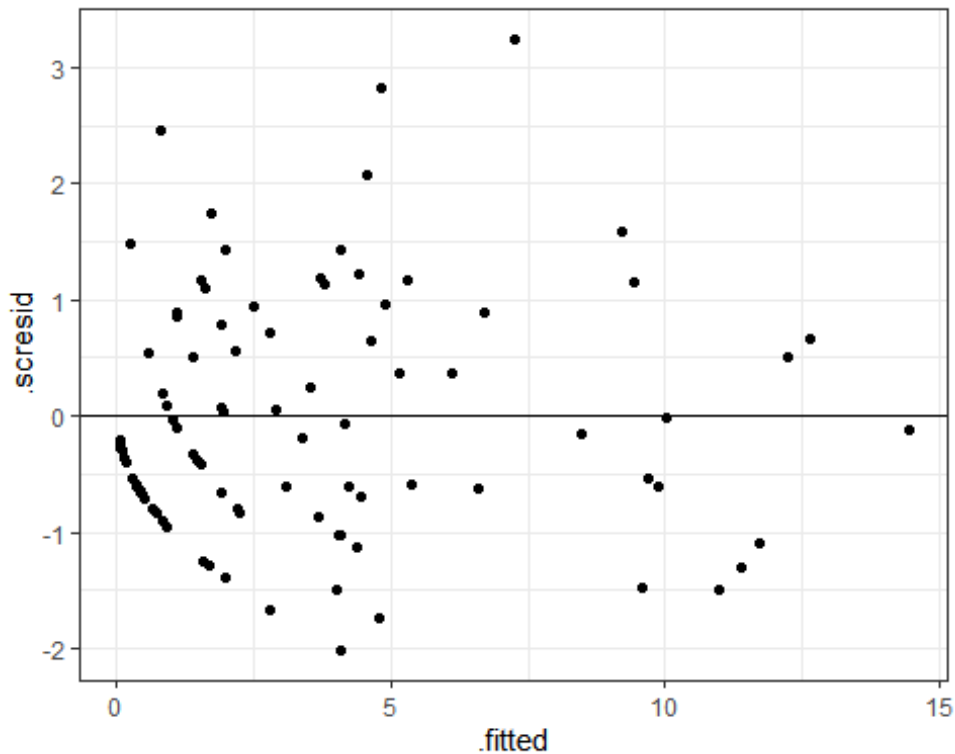
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.788
##      Conditional ICC: 0.653

AIC(M15,M15.1)

##      df      AIC
## M15    19 400.1398
## M15.1  17 398.9902

#См ниже анализ остатков для M15.1
model_diag3(M15.1)

```



```
M16=glmer(CountJ451~code+TBLogAvr+(1+TBLogAvr|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M16)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula: CountJ451 ~ code + TBLogAvr + (1 + TBLogAvr | year) + offset(lPop)
##   Data: PMdata
##
##           AIC          BIC    logLik deviance df.resid
##        399.4         448.5   -180.7    361.4         79
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0185 -0.6793 -0.3257  0.6450  2.8047
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year   (Intercept)      2.528    1.59
##          TBLogAvr      32832.504 181.20   -1.00
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.56452    0.62611 -12.082  < 2e-16 ***
## code2        0.10033    0.26541  0.378  0.70542
## code3        0.06518    0.27947  0.233  0.81557
## code4        1.04364    0.36756  2.839  0.00452 **
```

```

## code5      -0.34336    0.41683  -0.824  0.41009
## code6      0.60000    0.47334   1.268  0.20495
## code7     -0.11009    0.23458  -0.469  0.63884
## code8      0.98057    0.47828   2.050  0.04034 *
## code9      0.96598    0.21377   4.519 6.22e-06 ***
## code10     -0.01925    0.20204  -0.095  0.92411
## code11     0.26141    0.28550   0.916  0.35986
## code12     -0.33605    0.24171  -1.390  0.16444
## code13     -0.12390    0.29028  -0.427  0.66951
## code14     -1.07691    0.36690  -2.935  0.00333 **
## code15     -0.35508    0.27740  -1.280  0.20054
## TBLogAvr   -1.43107   74.90729  -0.019  0.98476
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M16)

## # Overdispersion test
##
##     dispersion ratio = 1.243
##   Pearson's Chi-Squared = 98.168
##           p-value = 0.071

## No overdispersion detected.

OverDisp2(M16)

## numeric(0)

icc(M16)

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
: Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

## Warning: mu of 1.0 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.686
##   Conditional ICC: 0.595

#основная модель
M16.1=glmer(CountJ451~code+TBLogAvr+(1|year)+offset(1Pop),
            family="poisson",PMdata, na.action=na.omit)
summary(M16.1)

```

```

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TBLogAvr + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    399.1    443.1   -182.6    365.1      81
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9968 -0.6719 -0.2815  0.6262  3.2485
##
## Random effects:
## Groups Name          Variance Std.Dev.
## year   (Intercept) 1.341     1.158
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.55106    0.52901 -14.274 < 2e-16 ***
## code2        0.14012    0.27125  0.517  0.60545
## code3        0.12557    0.28609  0.439  0.66073
## code4        1.22078    0.38101  3.204  0.00135 **
## code5       -0.19651    0.42711 -0.460  0.64544
## code6        0.67621    0.47766  1.416  0.15687
## code7       -0.05984    0.24008 -0.249  0.80316
## code8        1.12166    0.48389  2.318  0.02045 *
## code9        1.00125    0.21480  4.661 3.14e-06 ***
## code10       -0.02899    0.20144 -0.144  0.88557
## code11        0.29476    0.28552  1.032  0.30190
## code12       -0.27808    0.24175 -1.150  0.25003
## code13       -0.08773    0.29004 -0.302  0.76229
## code14       -0.99345    0.36855 -2.696  0.00703 **
## code15       -0.24170    0.27975 -0.864  0.38759
## TBLogAvr      5.28242   70.53518  0.075  0.94030
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M16.1)

## # Overdispersion test
##
##      dispersion ratio = 1.251
##      Pearson's Chi-Squared = 101.294
##      p-value = 0.063

## No overdispersion detected.

```

```

OverDisp1(M16.1)

## numeric(0)

icc(M16.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

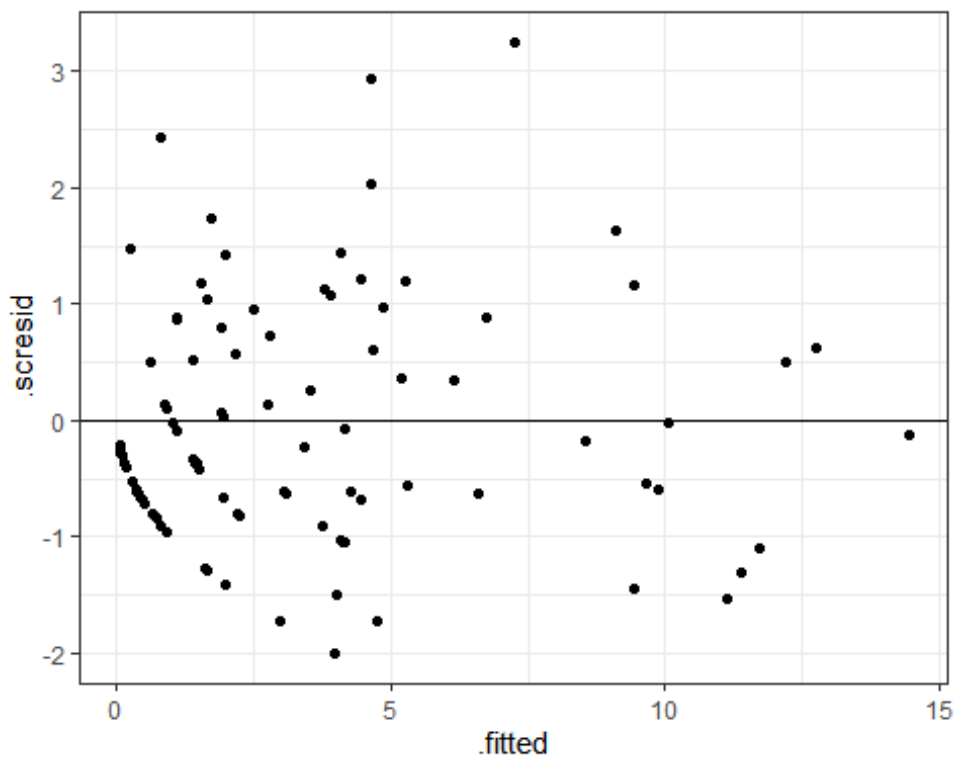
## # Intraclass Correlation Coefficient
##
##   Adjusted ICC: 0.787
##   Conditional ICC: 0.651

AIC(M16,M16.1)

##      df      AIC
## M16    19 399.3681
## M16.1  17 399.1100

#См ниже анализ остатков для M16.1
model_diag3(M16.1)

```



```

M17=glmer(CountJ451~code+TBPLogMax+(1+TBLogMax|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M17)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )

```

```

## Formula: CountJ451 ~ code + TBPLogMax + (1 + TBLogMax | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##    357.0    404.3  -159.5   319.0      70
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0785 -0.6282 -0.2557  0.4554  3.5681
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## year  (Intercept)  1.712   1.308
##      TBLogMax    255.631  15.988  -1.00
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.06754    0.60487 -13.338 < 2e-16 ***
## code2        0.69795    0.30580  2.282  0.02247 *
## code3        0.16885    0.34390  0.491  0.62343
## code4        1.44387    0.37093  3.893 9.92e-05 ***
## code5        0.01867    0.42582  0.044  0.96503
## code6        0.75671    0.47099  1.607  0.10813
## code7        0.27736    0.30788  0.901  0.36765
## code8        1.38074    0.48113  2.870  0.00411 **
## code9        1.09110    0.21919  4.978 6.43e-07 ***
## code10       -0.02521    0.20999  -0.120  0.90444
## code11       0.34956    0.29060  1.203  0.22901
## code12      -0.18876    0.25152  -0.750  0.45296
## code13      -0.01806    0.29807  -0.061  0.95167
## code14      -0.92643    0.36478  -2.540  0.01109 *
## code15      -0.08884    0.29001  -0.306  0.75934
## TBPLogMax    22.71524   15.22097  1.492  0.13560
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M17)

## # Overdispersion test
##
##      dispersion ratio = 1.236
##      Pearson's Chi-Squared = 86.536
##      p-value = 0.088

## No overdispersion detected.

OverDisp2(M17)

```

```

## numeric(0)

icc(M17)

## Warning: Random slopes not present as fixed effects. This artificially inflates the
## conditional random effect variances.
## Solution: Respecify fixed structure!

## Warning: mu of 1.1 is too close to zero, estimate of random effect variances may be
## unreliable.

## # Intraclass Correlation Coefficient
##
## Adjusted ICC: 0.720
## Conditional ICC: 0.613

#основная модель
M17.1=glmer(CountJ451~code+TBPLogMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M17.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + TBPLogMax + (1 | year) + offset(lPop)
## Data: PMdata
##
## AIC      BIC    logLik deviance df.resid
## 353.1    395.4   -159.6   319.1     72
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0791 -0.6205 -0.2546  0.4313  3.5285
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 1.396    1.182
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.017998  0.545784 -14.691 < 2e-16 ***
## code2        0.702771  0.305901  2.297 0.021597 *
## code3        0.169973  0.344357  0.494 0.621592
## code4        1.440043  0.371453  3.877 0.000106 ***
## code5        0.026871  0.425941  0.063 0.949697
## code6        0.754306  0.471083  1.601 0.109329
## code7        0.288439  0.306264  0.942 0.346295
## code8        1.396102  0.478929  2.915 0.003556 **
## code9        1.101289  0.217129  5.072 3.94e-07 ***
## code10       -0.006537  0.201987 -0.032 0.974180
## code11       0.363034  0.287707  1.262 0.207013

```



```

## code12      -0.178079    0.249662   -0.713  0.475673
## code13      -0.000310    0.293272   -0.001  0.999156
## code14      -0.927944    0.364825   -2.544  0.010974 *
## code15      -0.077992    0.288459   -0.270  0.786872
## TBPLogMax   19.249672   11.315185    1.701  0.088901 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M17.1)

## # Overdispersion test
##
##      dispersion ratio = 1.191
##      Pearson's Chi-Squared = 85.730
##      p-value = 0.129

## No overdispersion detected.

OverDisp1(M17.1)

## numeric(0)

icc(M17.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##      unreliable.

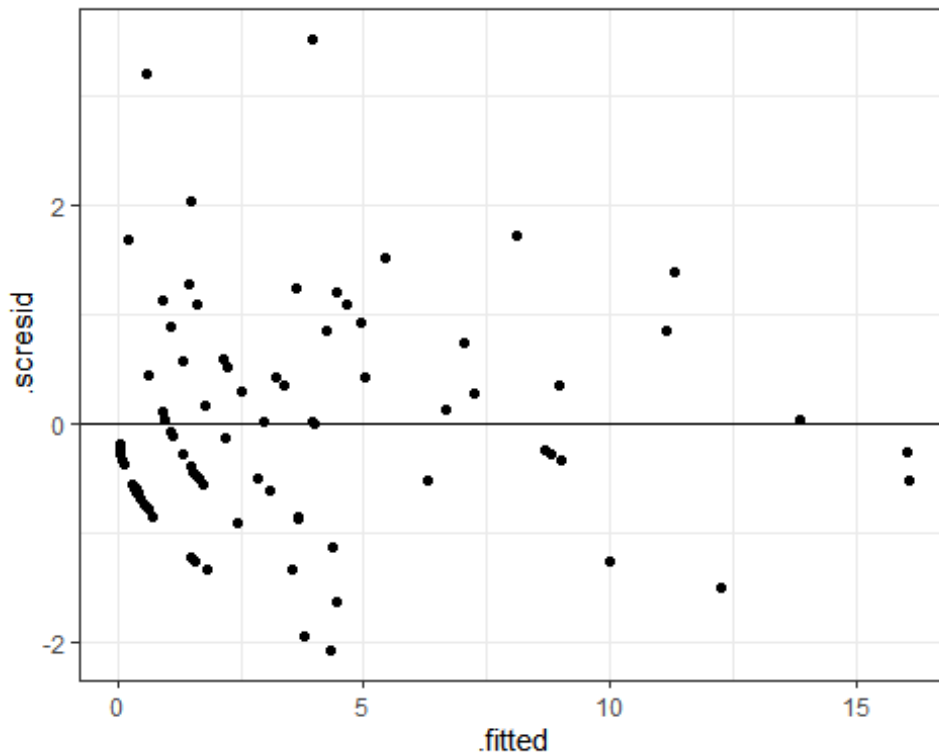
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.793
##      Conditional ICC: 0.643

AIC(M17,M17.1)

##      df      AIC
## M17    19 357.0073
## M17.1  17 353.1098

#См ниже анализ остатков для M17.1
model_diag3(M17.1)

```



```
M18=glmer(CountJ451~code+PLogMax+(1+PLogMax|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M18)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ451 ~ code + PLogMax + (1 + PLogMax | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC  logLik deviance df.resid
##  356.9   404.2  -159.5   318.9      70
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0791 -0.6332 -0.2351  0.4545  3.5713
##
## Random effects:
##  Groups Name      Variance Std.Dev. Corr
##  year  (Intercept)  1.841    1.357
##       PLogMax      292.810  17.112  -1.00
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.09305    0.62479 -12.953  < 2e-16 ***
## code2        0.69807    0.30533  2.286  0.022238 *
## code3        0.17001    0.34410  0.494  0.621252
## code4        1.45255    0.37882  3.834  0.000126 ***
```

```

## code5      0.02154    0.42592    0.051 0.959661
## code6      0.76205    0.47131    1.617 0.105908
## code7      0.27325    0.30746    0.889 0.374159
## code8      1.38037    0.48180    2.865 0.004170 **
## code9      1.08881    0.21782    4.999 5.77e-07 ***
## code10     -0.02567    0.20936   -0.123 0.902430
## code11     0.34488    0.28998    1.189 0.234311
## code12     -0.19233    0.25131   -0.765 0.444082
## code13     -0.01757    0.29737   -0.059 0.952884
## code14     -0.92352    0.36504   -2.530 0.011409 *
## code15     -0.09125    0.29131   -0.313 0.754102
## PLogMax    42.70202    27.21541    1.569 0.116639
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M18)

## # Overdispersion test
##
##     dispersion ratio = 1.238
##   Pearson's Chi-Squared = 86.690
##           p-value = 0.086

## No overdispersion detected.

OverDisp2(M18)

## numeric(0)

icc(M18)

## Warning: mu of 1.0 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.669
##   Conditional ICC: 0.561

#основная модель
M18.1=glmer(CountJ451~code+PLogMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M18.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: CountJ451 ~ code + PLogMax + (1 | year) + offset(lPop)
##   Data: PMdata

```

```

##
##      AIC      BIC   logLik deviance df.resid
##    353.2    395.5   -159.6    319.2      72
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0779 -0.6272 -0.2444  0.4326  3.5120
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year   (Intercept) 1.393    1.18
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.013841   0.546456 -14.665 < 2e-16 ***
## code2        0.702716   0.305971  2.297 0.021637 *
## code3        0.170394   0.344664  0.494 0.621040
## code4        1.466114   0.378263  3.876 0.000106 ***
## code5        0.027978   0.426899  0.066 0.947747
## code6        0.756788   0.471302  1.606 0.108331
## code7        0.289065   0.306383  0.943 0.345438
## code8        1.401724   0.480088  2.920 0.003503 **
## code9        1.099084   0.217039  5.064 4.11e-07 ***
## code10       0.001521   0.202362  0.008 0.994003
## code11       0.362918   0.287890  1.261 0.207449
## code12      -0.178155   0.250041 -0.713 0.476153
## code13       0.005549   0.294162  0.019 0.984950
## code14      -0.925443   0.365095 -2.535 0.011251 *
## code15      -0.075290   0.289859 -0.260 0.795059
## PLogMax     33.497609  20.040147  1.672 0.094618 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M18.1)

## # Overdispersion test
##
##      dispersion ratio = 1.189
##      Pearson's Chi-Squared = 85.635
##      p-value = 0.13

## No overdispersion detected.

OverDisp1(M18.1)

## numeric(0)

icc(M18.1)

```

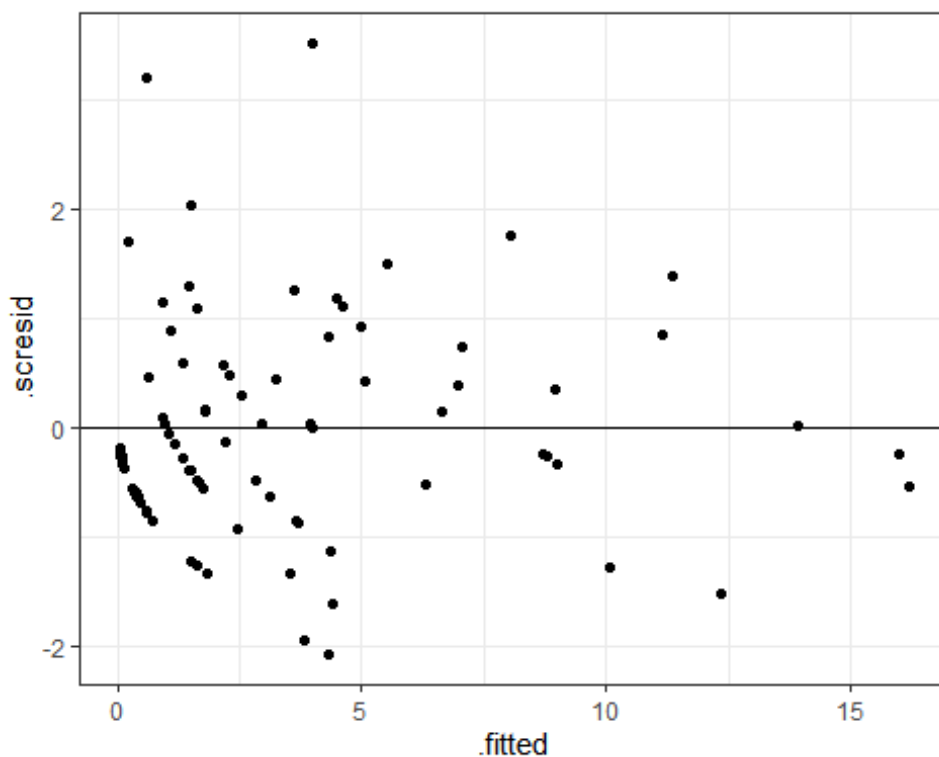
```
## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##       Adjusted ICC: 0.793
##       Conditional ICC: 0.643

AIC(M18,M18.1)

##           df           AIC
## M18       19 356.9486
## M18.1     17 353.1982

#См ниже анализ остатков для M18.1
model_diag3(M18.1)
```



```
M19=glmer(CountJ451~code+TBLogMax+(1+TBLogMax|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M19)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula: CountJ451 ~ code + TBLogMax + (1 + TBLogMax | year) + offset(lPop)
##   Data: PMdata
##
##           AIC           BIC    logLik deviance df.resid
##      357.0       404.3   -159.5    319.0         70
```

```

##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0826 -0.6195 -0.2536  0.4598  3.5806
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept)  1.675   1.294
##         TBlogMax    191.236  13.829  -1.00
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.049433   0.593698 -13.558 < 2e-16 ***
## code2        0.696927   0.305692   2.280 0.022618 *
## code3        0.163492   0.343414   0.476 0.634018
## code4        1.392708   0.362693   3.840 0.000123 ***
## code5        0.008616   0.424568   0.020 0.983810
## code6        0.749053   0.470589   1.592 0.111445
## code7        0.275813   0.307737   0.896 0.370113
## code8        1.367372   0.480229   2.847 0.004409 **
## code9        1.093390   0.219206   4.988 6.1e-07 ***
## code10       -0.035664   0.210778  -0.169 0.865639
## code11       0.348019   0.290373   1.199 0.230713
## code12       -0.192297   0.251142  -0.766 0.443861
## code13       -0.028308   0.298059  -0.095 0.924336
## code14       -0.933554   0.364379  -2.562 0.010406 *
## code15       -0.099584   0.288593  -0.345 0.730044
## TBlogMax     50.342218  33.563556   1.500 0.133638
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)      if you need it

check_overdispersion(M19)

## # Overdispersion test
##
##      dispersion ratio = 1.236
##      Pearson's Chi-Squared = 86.551
##      p-value = 0.087

## No overdispersion detected.

OverDisp2(M19)

## numeric(0)

icc(M19)

```

```
## Warning: mu of 1.1 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##       Adjusted ICC: 0.683
##       Conditional ICC: 0.571

#основная модель
M19.1=glmer(CountJ451~code+TBLogMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M19.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula: CountJ451 ~ code + TBLogMax + (1 | year) + offset(lPop)
##   Data: PMdata
##
##           AIC           BIC    logLik deviance df.resid
##        353.1         395.4   -159.5    319.1         72
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0822 -0.6137 -0.2542  0.4391  3.5448
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.403      1.185
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.00887    0.54383 -14.727 < 2e-16 ***
## code2        0.70110    0.30576  2.293 0.021849 *
## code3        0.16555    0.34380  0.482 0.630137
## code4        1.39732    0.36291  3.850 0.000118 ***
## code5        0.01779    0.42425  0.042 0.966553
## code6        0.74846    0.47070  1.590 0.111814
## code7        0.28575    0.30605  0.934 0.350466
## code8        1.38297    0.47736  2.897 0.003766 **
## code9        1.10223    0.21719  5.075 3.87e-07 ***
## code10       -0.01799    0.20171 -0.089 0.928953
## code11       0.36017    0.28738  1.253 0.210095
## code12       -0.18199    0.24894 -0.731 0.464738
## code13       -0.01094    0.29213 -0.037 0.970130
## code14       -0.93355    0.36446 -2.561 0.010423 *
## code15       -0.08774    0.28620 -0.307 0.759173
## TBLogMax     43.76897    25.68967  1.704 0.088426 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M19.1)

## # Overdispersion test
##
##     dispersion ratio = 1.192
##     Pearson's Chi-Squared = 85.846
##     p-value = 0.127

## No overdispersion detected.

OverDisp1(M19.1)

## numeric(0)

icc(M19.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##     unreliable.

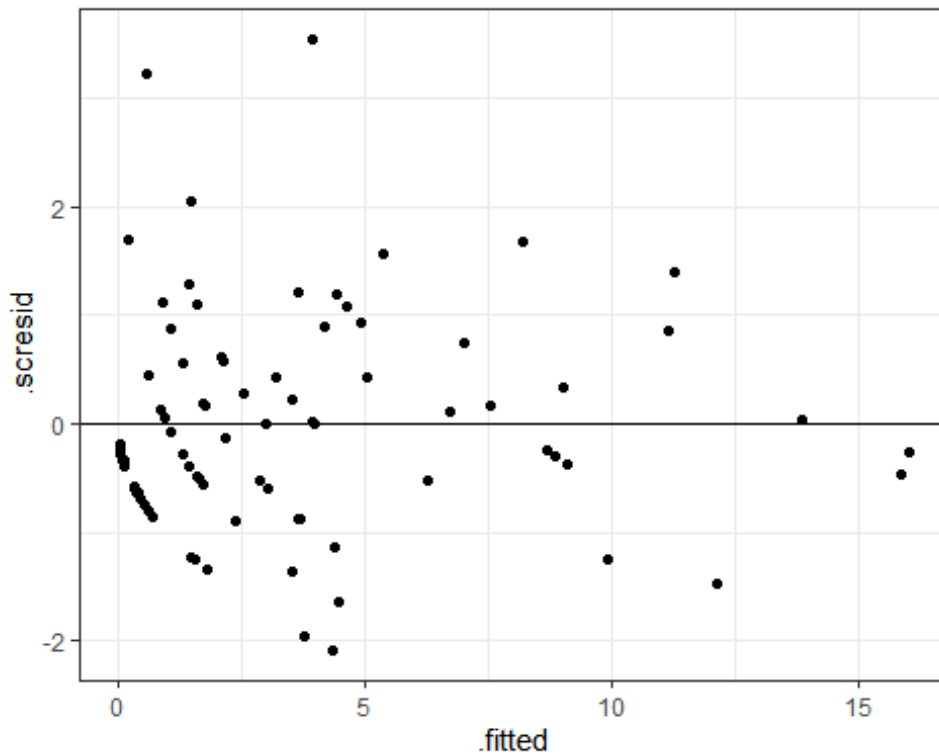
## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.794
##     Conditional ICC: 0.645

AIC(M19,M19.1)

##      df      AIC
## M19   19 357.0038
## M19.1 17 353.0850

#См ниже анализ остатков для M19.1
model_diag3(M19.1)

```

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение

```
M20.1=glmer(CountJ450~code+TBPLogMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M20.1)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
##   Formula: CountJ450 ~ code + TBPLogMax + (1 | year) + offset(lPop)
##   Data: PMdata
##
##           AIC          BIC    logLik deviance df.resid
##       728.7       771.0   -347.3    694.7        72
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.3982 -1.0989 -0.2091  0.8407  7.3131
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept)  0.3227    0.5681
## Number of obs: 89, groups:  year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -6.02063    0.24799 -24.277  < 2e-16 ***
## code2        1.11860    0.11544  9.690  < 2e-16 ***
## code3        0.29373    0.13503  2.175  0.02962 *
## code4        1.52076    0.15674  9.703  < 2e-16 ***
```

```

## code5      0.81064    0.13713    5.912 3.39e-09 ***
## code6     -0.15495    0.30844   -0.502 0.61542
## code7      0.33180    0.12633    2.626 0.00863 **
## code8      0.27370    0.34083    0.803 0.42196
## code9      0.77270    0.10197    7.578 3.52e-14 ***
## code10     -0.18805    0.08970   -2.096 0.03604 *
## code11     -0.04053    0.14152   -0.286 0.77456
## code12      0.21637    0.09552    2.265 0.02351 *
## code13      0.29781    0.11056    2.694 0.00707 **
## code14     -0.36057    0.12530   -2.878 0.00401 **
## code15      0.21015    0.11559    1.818 0.06905 .
## TBPLogMax  20.20894    4.75912    4.246 2.17e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M20.1)

## # Overdispersion test
##
##     dispersion ratio =    4.211
##   Pearson's Chi-Squared = 303.209
##           p-value = < 0.001

## Overdispersion detected.

OverDisp1(M20.1)

## numeric(0)

icc(M20.1)

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.858
##     Conditional ICC: 0.530

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M21.1=glmer(CountJ450~code+PLogMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M21.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: poisson ( log )
## Formula: CountJ450 ~ code + PLogMax + (1 | year) + offset(lPop)
##   Data: PMdata
##
##           AIC          BIC    logLik deviance df.resid
##        727.6         769.9    -346.8     693.6         72

```

```

##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.3299 -1.0916 -0.2367  0.8873  7.3105
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year  (Intercept) 0.3201   0.5658
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -6.03530    0.24757 -24.378 < 2e-16 ***
## code2        1.12629    0.11567  9.737 < 2e-16 ***
## code3        0.30220    0.13531  2.233 0.02552 *
## code4        1.55423    0.15913  9.767 < 2e-16 ***
## code5        0.82441    0.13778  5.983 2.19e-09 ***
## code6       -0.14808    0.30851 -0.480 0.63125
## code7        0.33467    0.12637  2.648 0.00809 **
## code8        0.28667    0.34108  0.840 0.40064
## code9        0.77296    0.10196  7.581 3.43e-14 ***
## code10       -0.17944    0.08962 -2.002 0.04526 *
## code11       -0.03751    0.14156 -0.265 0.79102
## code12        0.22101    0.09567  2.310 0.02088 *
## code13        0.30680    0.11077  2.770 0.00561 **
## code14       -0.35600    0.12539 -2.839 0.00453 **
## code15        0.21911    0.11600  1.889 0.05891 .
## PLogMax      36.63883    8.40187  4.361 1.30e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M21.1)

## # Overdispersion test
##
##      dispersion ratio = 4.209
##      Pearson's Chi-Squared = 303.036
##      p-value = < 0.001

## Overdispersion detected.

OverDisp1(M21.1)

## numeric(0)

icc(M21.1)

## # Intraclass Correlation Coefficient
##

```

```

## Adjusted ICC: 0.857
## Conditional ICC: 0.527

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M22.1=glmer(CountJ450~code+TBLogMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M22.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ450 ~ code + TBLogMax + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##  730.6    772.9   -348.3    696.6      72
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.4924 -1.1096 -0.1730  0.8548  7.3095
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.3259   0.5709
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.98686    0.24763 -24.177 < 2e-16 ***
## code2        1.10619    0.11508  9.612 < 2e-16 ***
## code3        0.27922    0.13457  2.075  0.03800 *
## code4        1.47088    0.15347  9.584 < 2e-16 ***
## code5        0.78565    0.13590  5.781 7.42e-09 ***
## code6       -0.16636    0.30833 -0.540  0.58951
## code7        0.32648    0.12625  2.586  0.00971 **
## code8        0.25303    0.34048  0.743  0.45739
## code9        0.77054    0.10196  7.558 4.11e-14 ***
## code10       -0.19773    0.08989 -2.200  0.02782 *
## code11       -0.04590    0.14146 -0.324  0.74558
## code12       0.20698    0.09522  2.174  0.02973 *
## code13       0.28548    0.11031  2.588  0.00965 **
## code14      -0.36855    0.12516 -2.945  0.00323 **
## code15       0.19300    0.11477  1.682  0.09263 .
## TBLogMax    43.40400    10.76793  4.031 5.56e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M22.1)

```

```
## # Overdispersion test
##
##      dispersion ratio =    4.220
##      Pearson's Chi-Squared = 303.870
##      p-value = < 0.001

## Overdispersion detected.

OverDisp1(M22.1)

## numeric(0)

icc(M22.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.859
##      Conditional ICC: 0.535

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M23=glmer(CountJ458~code+PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M23)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ458 ~ code + PM.2.5Max + (1 + PM.2.5Max | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##  1035.7   1083.8   -498.8    997.7      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.7730 -1.5781 -0.1945  1.2668  8.3350
##
## Random effects:
##  Groups Name            Variance Std.Dev. Corr
##  year  (Intercept)    0.5143   0.7172
##        PM.2.5Max    25.2209   5.0220  -0.93
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.69034    0.29763 -19.119 < 2e-16 ***
## code2        0.11033    0.12648  0.872  0.38303
## code3        0.26120    0.11856  2.203  0.02759 *
## code4        1.44594    0.13850 10.440 < 2e-16 ***
## code5        0.76271    0.12318  6.192 5.95e-10 ***
## code6       -0.05635    0.26556 -0.212  0.83195
## code7        0.92995    0.08955 10.384 < 2e-16 ***
## code8        0.37303    0.27689  1.347  0.17791
## code9        1.01098    0.08824 11.458 < 2e-16 ***
```

```

## code10      0.02471    0.08167    0.303    0.76221
## code11      0.45214    0.11039    4.096 4.21e-05 ***
## code12      0.74298    0.07708    9.639 < 2e-16 ***
## code13      0.45703    0.10346    4.417 9.99e-06 ***
## code14     -0.35014    0.11303   -3.098 0.00195 **
## code15     -0.03366    0.11888   -0.283 0.77705
## PM.2.5Max    2.14660    1.98576    1.081 0.27970
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M23)

## # Overdispersion test
##
##      dispersion ratio =    7.021
##      Pearson's Chi-Squared = 519.553
##      p-value = < 0.001

## Overdispersion detected.

OverDisp1(M23)

## numeric(0)

icc(M23)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.826
##      Conditional ICC: 0.406

M23.1=glmer(CountJ458~code+PM.2.5Max+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M23.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ458 ~ code + PM.2.5Max + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##  1106.6   1149.6   -536.3   1072.6      76
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -4.8113 -1.9243 -0.2882  1.3008 10.4791
##
## Random effects:

```

```

## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.07177  0.2679
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##           Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.22079    0.13462 -38.782 < 2e-16 ***
## code2        0.10814    0.11515  0.939  0.34768
## code3        0.17051    0.11302  1.509  0.13138
## code4        1.30961    0.13314  9.836 < 2e-16 ***
## code5        0.58410    0.11728  4.980 6.35e-07 ***
## code6       -0.19188    0.26449 -0.725  0.46817
## code7        0.71081    0.08263  8.603 < 2e-16 ***
## code8        0.18463    0.27406  0.674  0.50050
## code9        0.81622    0.08347  9.778 < 2e-16 ***
## code10      -0.03965    0.07598 -0.522  0.60172
## code11       0.28491    0.10337  2.756  0.00585 **
## code12       0.62410    0.06995  8.923 < 2e-16 ***
## code13       0.28750    0.09560  3.007  0.00264 **
## code14      -0.47517    0.11135 -4.267 1.98e-05 ***
## code15      -0.24968    0.11373 -2.195  0.02814 *
## PM.2.5Max    0.09554    0.38040  0.251  0.80170
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M23.1)

## # Overdispersion test
##
##           dispersion ratio =    8.305
##      Pearson's Chi-Squared = 631.161
##           p-value = < 0.001

## Overdispersion detected.

OverDisp1(M23.1)

## numeric(0)

icc(M23.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.678
##      Conditional ICC: 0.224

AIC(M23,M23.1)

```

```

##      df      AIC
## M23    19 1035.660
## M23.1  17 1106.569

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M24=glmer(CountJ458~code+PM.10Max+(1+PM.10Max|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)
summary(M24)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ458 ~ code + PM.10Max + (1 + PM.10Max | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##  1016.7   1064.9   -489.4    978.7      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.4481 -1.5715 -0.1105  1.4163  8.7793
##
## Random effects:
## Groups Name             Variance Std.Dev. Corr
## year   (Intercept)  0.6148    0.7841
##        PM.10Max    7.1066    2.6658   -0.94
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.65033    0.32102 -17.601  < 2e-16 ***
## code2        0.08981    0.12579   0.714   0.4753
## code3        0.22869    0.11901   1.922   0.0547 .
## code4        1.43168    0.13830  10.352  < 2e-16 ***
## code5        0.73002    0.12082   6.042 1.52e-09 ***
## code6       -0.05812    0.26584  -0.219   0.8269
## code7        0.91342    0.08865  10.304  < 2e-16 ***
## code8        0.38588    0.27610   1.398   0.1622
## code9        1.00561    0.09022  11.146  < 2e-16 ***
## code10       0.09956    0.08167   1.219   0.2228
## code11       0.49570    0.10812   4.585 4.54e-06 ***
## code12       0.71608    0.07583   9.443  < 2e-16 ***
## code13       0.47100    0.10290   4.577 4.71e-06 ***
## code14      -0.33230    0.11381  -2.920   0.0035 **
## code15      -0.02857    0.11868  -0.241   0.8098
## PM.10Max     0.99027    1.05437   0.939   0.3476
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

```



```

check_overdispersion(M24)

## # Overdispersion test
##
##      dispersion ratio =    6.868
##      Pearson's Chi-Squared = 508.199
##      p-value = < 0.001

## Overdispersion detected.

OverDisp1(M24)

## numeric(0)

icc(M24)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.796
##      Conditional ICC: 0.371

M24.1=glmer(CountJ458~code+PM.10Max+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M24.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ458 ~ code + PM.10Max + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC   logLik deviance df.resid
##  1101.6   1144.6  -533.8   1067.6      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.8861 -1.9078 -0.2194  1.1938 11.1806
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.07066  0.2658
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.41029    0.14728 -36.736 < 2e-16 ***
## code2        0.19531    0.11980  1.630  0.10304
## code3        0.23955    0.11620  2.061  0.03926 *
## code4        1.41772    0.13660 10.379 < 2e-16 ***
## code5        0.67612    0.11952  5.657 1.54e-08 ***
## code6       -0.13370    0.26535  -0.504  0.61437
## code7        0.74471    0.08388  8.879 < 2e-16 ***
## code8        0.26815    0.27570  0.973  0.33074
## code9        0.85813    0.08517 10.075 < 2e-16 ***

```

```

## code10      -0.04070      0.07595  -0.536   0.59209
## code11       0.29257      0.10313   2.837   0.00455 **
## code12       0.64821      0.07081   9.154   < 2e-16 ***
## code13       0.31257      0.09598   3.257   0.00113 **
## code14      -0.44009      0.11213  -3.925  8.69e-05 ***
## code15      -0.17815      0.11594  -1.537   0.12441
## PM.10Max     0.57939      0.25690   2.255   0.02411 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

check_overdispersion(M24.1)

## # Overdispersion test
##
##      dispersion ratio =    8.297
##      Pearson's Chi-Squared = 630.569
##      p-value = < 0.001

## Overdispersion detected.

OverDisp1(M24.1)

## numeric(0)

icc(M24.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.675
##      Conditional ICC: 0.220

AIC(M24,M24.1)

##      df      AIC
## M24    19 1016.750
## M24.1  17 1101.553

#Сверхдисперсия!Необходимо посмотреть отрицательное биномиальное распределение
M25=glmer(CountJ458~code+TSPMax+(1+TSPMax|year)+offset(lPop),
          family="poisson",PMdata, na.action=na.omit)

## boundary (singular) fit: see ?isSingular

summary(M25)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ458 ~ code + TSPMax + (1 + TSPMax | year) + offset(lPop)
## Data: PMdata

```

```

##
##      AIC      BIC   logLik deviance df.resid
##    1104.9    1153.0   -533.4   1066.9      74
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.7562 -1.9798 -0.2766  1.4640 10.2710
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept) 0.17528  0.4187
##         TSPMax      0.09019  0.3003  -1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -4.975611   0.211528 -23.522 < 2e-16 ***
## code2        -0.010198   0.128568  -0.079  0.93678
## code3         0.117896   0.116282   1.014  0.31064
## code4         1.167467   0.144238   8.094 5.77e-16 ***
## code5         0.498735   0.120766   4.130 3.63e-05 ***
## code6        -0.204856   0.265013  -0.773  0.43952
## code7         0.722401   0.083337   8.668 < 2e-16 ***
## code8         0.167821   0.273852   0.613  0.54000
## code9         0.793191   0.084026   9.440 < 2e-16 ***
## code10        -0.001356   0.077534  -0.017  0.98604
## code11         0.305501   0.104069   2.936  0.00333 **
## code12         0.632640   0.071329   8.869 < 2e-16 ***
## code13         0.305155   0.096457   3.164  0.00156 **
## code14        -0.515488   0.112805  -4.570 4.88e-06 ***
## code15        -0.317381   0.119574  -2.654  0.00795 **
## TSPMax        -0.411057   0.245478  -1.675  0.09403 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

## optimizer (Nelder_Mead) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular

check_overdispersion(M25)

## # Overdispersion test
##
##      dispersion ratio = 8.465
##      Pearson's Chi-Squared = 626.398
##      p-value = < 0.001

## Overdispersion detected.

OverDisp1(M25)

```

```
## numeric(0)

icc(M25)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.658
##      Conditional ICC: 0.226

M25.1=glmer(CountJ458~code+TSPMax+(1|year)+offset(lPop),
            family="poisson",PMdata, na.action=na.omit)
summary(M25.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: poisson ( log )
## Formula: CountJ458 ~ code + TSPMax + (1 | year) + offset(lPop)
## Data: PMdata
##
##      AIC      BIC    logLik deviance df.resid
##  1104.0   1147.1   -535.0   1070.0      76
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.8099 -1.9822 -0.2852  1.3457 10.4741
##
## Random effects:
## Groups Name          Variance Std.Dev.
## year  (Intercept) 0.07054  0.2656
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -4.992956   0.172860 -28.884 < 2e-16 ***
## code2        0.009453   0.126733  0.075  0.94054
## code3        0.114515   0.115965  0.988  0.32340
## code4        1.186112   0.143859  8.245 < 2e-16 ***
## code5        0.494898   0.120843  4.095 4.21e-05 ***
## code6       -0.228933   0.264674 -0.865  0.38706
## code7        0.703300   0.082572  8.517 < 2e-16 ***
## code8        0.146432   0.273506  0.535  0.59238
## code9        0.790808   0.084112  9.402 < 2e-16 ***
## code10      -0.022553   0.076627 -0.294  0.76851
## code11       0.281940   0.103024  2.737  0.00621 **
## code12       0.611052   0.070325  8.689 < 2e-16 ***
## code13       0.278640   0.095286  2.924  0.00345 **
## code14      -0.510055   0.112699 -4.526 6.02e-06 ***
## code15      -0.328233   0.118983 -2.759  0.00580 **
## TSPMax      -0.353440   0.217620 -1.624  0.10435
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

check_overdispersion(M25.1)

## # Overdispersion test
##
##     dispersion ratio =    8.271
##   Pearson's Chi-Squared = 628.576
##           p-value = < 0.001

## Overdispersion detected.

OverDisp1(M25.1)

## numeric(0)

icc(M25.1)

## # Intraclass Correlation Coefficient
##
##     Adjusted ICC: 0.674
##   Conditional ICC: 0.219

AIC(M25,M25.1)

##      df      AIC
## M25   19 1104.883
## M25.1 17 1104.008

#отрицательное биномиальное распределение, так как избыточная дисперсия в пуассоновских моделях

# ## Проверка на сверхдисперсию
# Функция для проверки наличия сверхдисперсии в модели (автор Ben Bolker)
# http://bbolker.github.io/mixedmodels-misc/glmmFAQ.html
# Код модифицирован, чтобы учесть дополнительный параметр в NegBin GLMM, подобранных MASS::glm.nb()
overdisp_fun <- function(model) {
  rdf <- df.residual(model) # Число степеней свободы N - p
  if (any(class(model) == 'negbin')) rdf <- rdf - 1 ## учитываем k в NegBin GLMM
  rp <- residuals(model,type='pearson') # Пирсоновские остатки
  Pearson.chisq <- sum(rp^2) # Сумма квадратов остатков, подчиняется Хи-квадрат
  распределению
  pratt <- Pearson.chisq/rdf # Отношение суммы квадратов остатков к числу степеней
  свободы
  pval <- pchisq(Pearson.chisq, df=rdf, lower.tail=FALSE) # Уровень значимости
  c(chisq=Pearson.chisq, ratio=pratt, rdf=rdf, p=pval) # Вывод результатов
}

#data <- read.csv('PMdata4.csv', header=TRUE, sep=';', dec = ",")
#data$year <- as.factor(data$year)
```

```

#data$code <- as.factor(data$code)

Mod0=glmer.nb(CountJBA~PM.2.5Max+(1+PM.2.5Max|year)+offset(1Pop),PMdata,
              control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular

isSingular(Mod0)

## [1] TRUE

Mod0.1=glmer.nb(CountJBA~PM.2.5Max+(1|year)+offset(1Pop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 
200000)))
isSingular(Mod0.1)

## [1] FALSE

summary(Mod0.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(2.8205) ( log )
## Formula: CountJBA ~ PM.2.5Max + (1 | year) + offset(1Pop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    830.1    840.3   -411.1    822.1      89
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.2765 -0.6837 -0.2084  0.3674  4.9434
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year  (Intercept) 0.07845  0.2801
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -4.0817    0.1886  -21.64  <2e-16 ***
## PM.2.5Max    -1.7210    1.0006   -1.72   0.0854 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr)
## PM.2.5Max  -0.749
overdisp_fun(Mod0.1)

```

```
##          chisq          ratio          rdf          p
## 108.29592004    1.21680809   89.00000000    0.08039427
```

```
AIC(Mod0, Mod0.1)
```

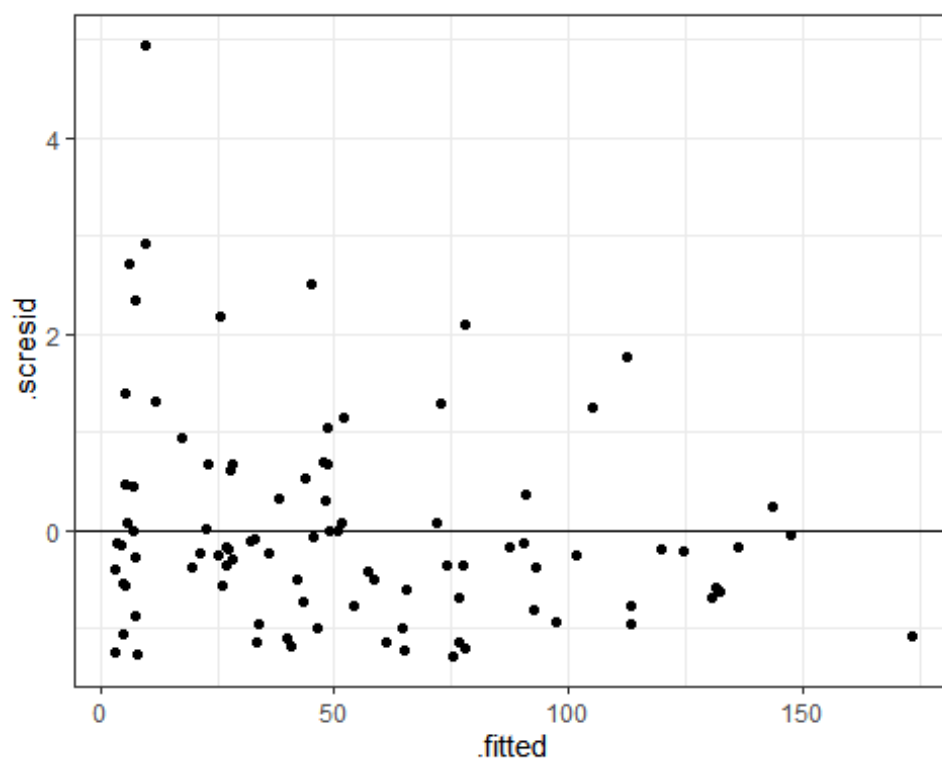
```
##          df          AIC
## Mod0      6 837.9068
## Mod0.1    4 830.1270
```

```
getME(Mod0.1, 'glmer.nb.theta')
```

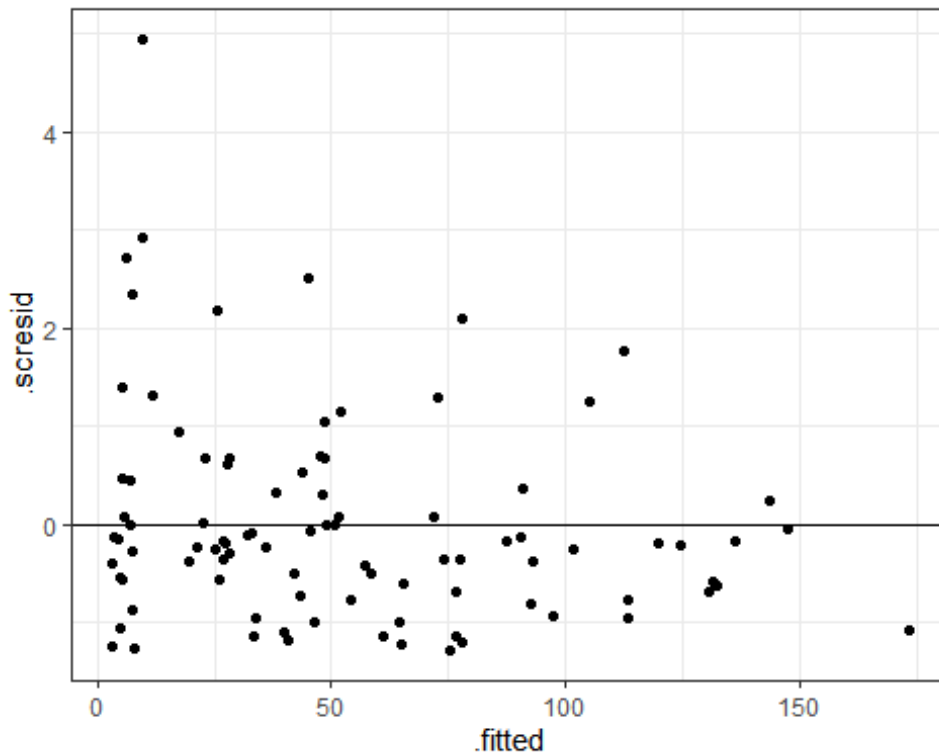
```
## [1] 2.820496
```

#Модель Mod0.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M0.1:без пропусков/с пропусками
`model_diag(Mod0.1)`



```
model_diag3(Mod0.1)
```



```
Mod14=glmer.nb(CountJ451~code+PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

## boundary (singular) fit: see ?isSingular

isSingular(Mod14)

## [1] TRUE

Mod14.1=glmer.nb(CountJ451~code+PM.2.5Max+(1|year)+offset(lPop),PMdata,
                control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

isSingular(Mod14.1)

## [1] FALSE

summary(Mod14.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(36.7736) ( log )
## Formula: CountJ451 ~ code + PM.2.5Max + (1 | year) + offset(lPop)
## Data: PMdata
```



```

## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    364.6    410.2   -164.3    328.6      75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8435 -0.6102 -0.2736  0.4276  3.4793
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.409      1.187
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.070897   0.551474 -14.635 < 2e-16 ***
## code2        0.694381   0.344181   2.017 0.043645 *
## code3        0.198681   0.365308   0.544 0.586529
## code4        1.476612   0.390536   3.781 0.000156 ***
## code5        0.045527   0.440011   0.103 0.917591
## code6        0.760432   0.486094   1.564 0.117730
## code7        0.267321   0.341469   0.783 0.433713
## code8        1.294739   0.492796   2.627 0.008606 **
## code9        1.066877   0.239808   4.449 8.63e-06 ***
## code10       0.030506   0.228521   0.133 0.893803
## code11       0.277620   0.306933   0.904 0.365731
## code12      -0.201575   0.256974  -0.784 0.432794
## code13      -0.000199   0.313647  -0.001 0.999494
## code14      -0.926983   0.382178  -2.426 0.015286 *
## code15      -0.054202   0.309555  -0.175 0.861004
## PM.2.5Max    2.537146   1.318812   1.924 0.054378 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod14.1)

##      chisq      ratio      rdf      p
## 83.328899  1.111052 75.000000 0.238736

getME(Mod14.1, 'glmer.nb.theta')

## [1] 36.77356

icc(Mod14.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

```

```
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.787
##      Conditional ICC: 0.649

#Модель M2.1 (распределение Пуассона) лучше подходит для данных!!! См. выше

Mod15=glmer.nb(CountJ450~PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular

isSingular(Mod15)

## [1] TRUE

Mod15.1=glmer.nb(CountJ450~PM.2.5Max+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
isSingular(Mod15.1)

## [1] FALSE

summary(Mod15.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(2.7185) ( log )
## Formula: CountJ450 ~ PM.2.5Max + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    675.7    685.8   -333.8    667.7      89
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.3732 -0.7116 -0.1940  0.3150  3.6766
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.3133   0.5598
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -4.989      0.276  -18.079  <2e-16 ***
## PM.2.5Max     -2.113      1.124   -1.879   0.0602 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```

```
##          (Intr)
## PM.2.5Max -0.585
```

```
overdisp_fun(Mod15.1)
```

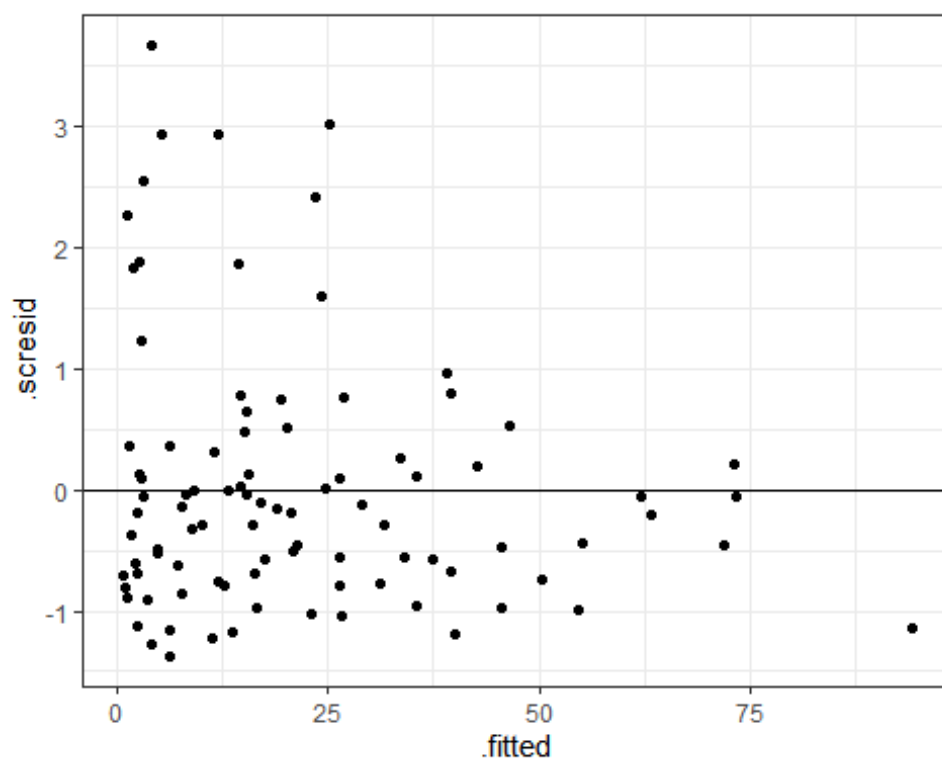
```
##          chisq          ratio          rdf          p
## 106.95375704    1.20172761    89.00000000    0.09446335
```

```
AIC(Mod15, Mod15.1)
```

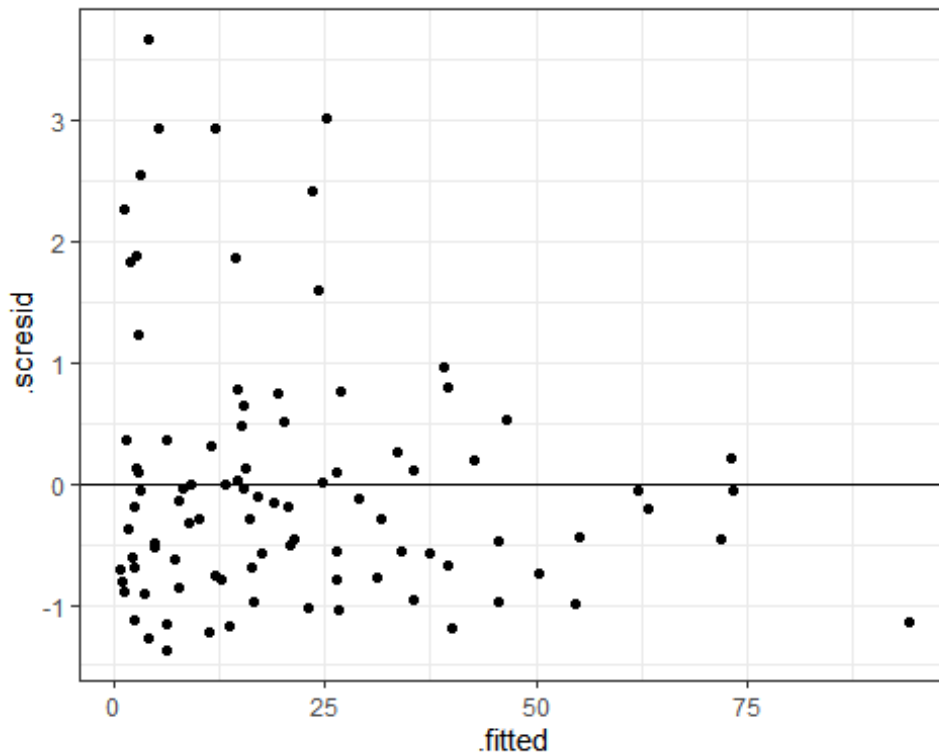
```
##          df          AIC
## Mod15      6 679.6560
## Mod15.1    4 675.6975
```

#Модель Mod15.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M15.1:без пропусков/с пропусками
model_diag(Mod15.1)



```
model_diag3(Mod15.1)
```



```
Mod16=glmer.nb(CountJ451~code+PM.10Max+(1+PM.10Max|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

## boundary (singular) fit: see ?isSingular

isSingular(Mod16)

## [1] TRUE

Mod16.1=glmer.nb(CountJ451~code+PM.10Max+(1|year)+offset(lPop),PMdata,
                control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

isSingular(Mod16.1)

## [1] FALSE

summary(Mod16.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(45.6412) ( log )
## Formula: CountJ451 ~ code + PM.10Max + (1 | year) + offset(lPop)
## Data: PMdata
```

```
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    365.3    410.9   -164.7    329.3      75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8167 -0.6087 -0.2423  0.5174  3.3093
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year   (Intercept) 1.417    1.19
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.096336   0.571243 -14.173 < 2e-16 ***
## code2        0.717261   0.340606   2.106 0.035219 *
## code3        0.209714   0.364436   0.575 0.564988
## code4        1.480911   0.395029   3.749 0.000178 ***
## code5        0.020097   0.437819   0.046 0.963387
## code6        0.771663   0.484818   1.592 0.111462
## code7        0.290184   0.337711   0.859 0.390193
## code8        1.316895   0.495274   2.659 0.007839 **
## code9        1.080705   0.237333   4.554 5.27e-06 ***
## code10       0.038456   0.224302   0.171 0.863873
## code11       0.263130   0.302036   0.871 0.383653
## code12      -0.177004   0.256190  -0.691 0.489622
## code13       0.001531   0.310672   0.005 0.996067
## code14      -0.908664   0.380514  -2.388 0.016941 *
## code15      -0.046334   0.310982  -0.149 0.881559
## PM.10Max     1.407816   0.809596   1.739 0.082050 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod16.1)

##      chisq      ratio      rdf      p
## 83.412520  1.112167 75.000000 0.236769

getME(Mod16.1, 'glmer.nb.theta')

## [1] 45.64125

icc(Mod16.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
## unreliable.
```

```
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.789
##      Conditional ICC: 0.654

#Модель М3.1 (распределение Пуассона) лучше подходит для данных!!! См. выше

Mod17=glmer.nb(CountJ450~code+PM.10Max+(1+PM.10Max|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular

isSingular(Mod17)

## [1] TRUE

Mod17.1=glmer.nb(CountJ450~code+PM.10Max+(1|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
isSingular(Mod17.1)

## [1] FALSE

summary(Mod17.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6) ( log )
## Formula: CountJ450 ~ code + PM.10Max + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    656.7    702.3   -310.3    620.7      75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8355 -0.6894 -0.1129  0.4209  3.3983
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.2997   0.5475
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.71599    0.36189 -15.795 < 2e-16 ***
## code2        0.95505    0.32642  2.926 0.003436 **
## code3        0.24897    0.29171  0.853 0.393383
## code4        1.40226    0.30410  4.611 4e-06 ***
## code5        0.76086    0.28578  2.662 0.007759 **
## code6       -0.07813    0.39045 -0.200 0.841404
```

```
## code7      0.37058    0.32396    1.144 0.252665
## code8      0.28093    0.39715    0.707 0.479333
## code9      0.82867    0.24657    3.361 0.000777 ***
## code10     -0.06060    0.24088   -0.252 0.801370
## code11     -0.12279    0.26572   -0.462 0.644006
## code12      0.30318    0.24605    1.232 0.217867
## code13      0.23256    0.25002    0.930 0.352299
## code14     -0.27432    0.25967   -1.056 0.290780
## code15      0.11640    0.28127    0.414 0.678986
## PM.10Max    0.21144    0.70437    0.300 0.764044
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
overdisp_fun(Mod17.1)
```

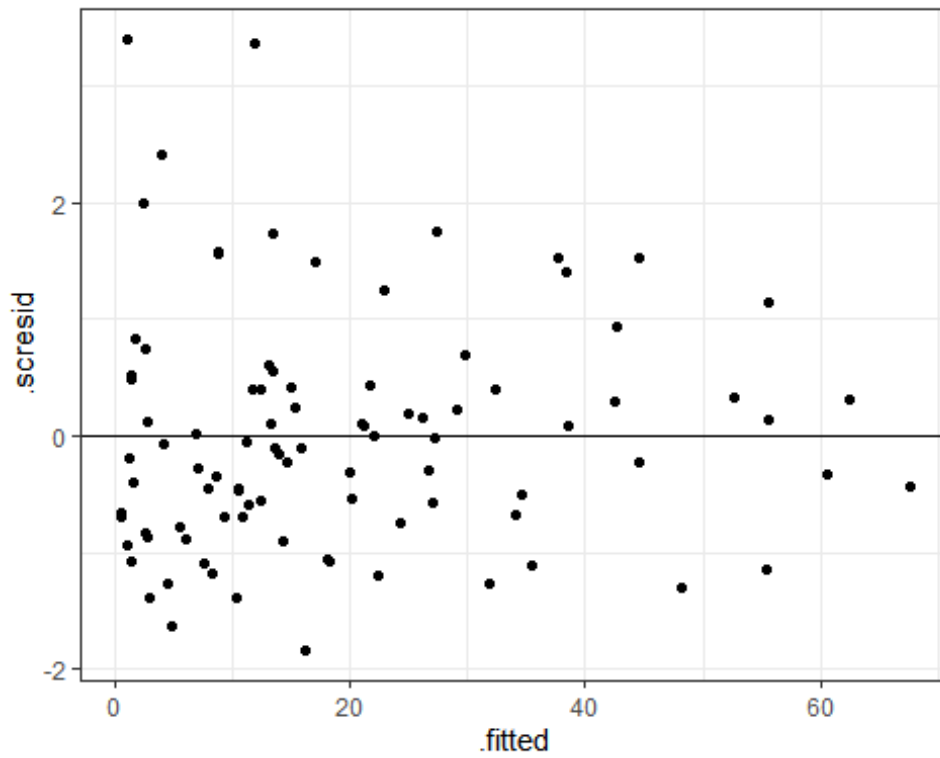
```
##      chisq      ratio      rdf      p
## 95.8742996  1.2783240 75.0000000 0.0524953
```

```
AIC(Mod17, Mod17.1)
```

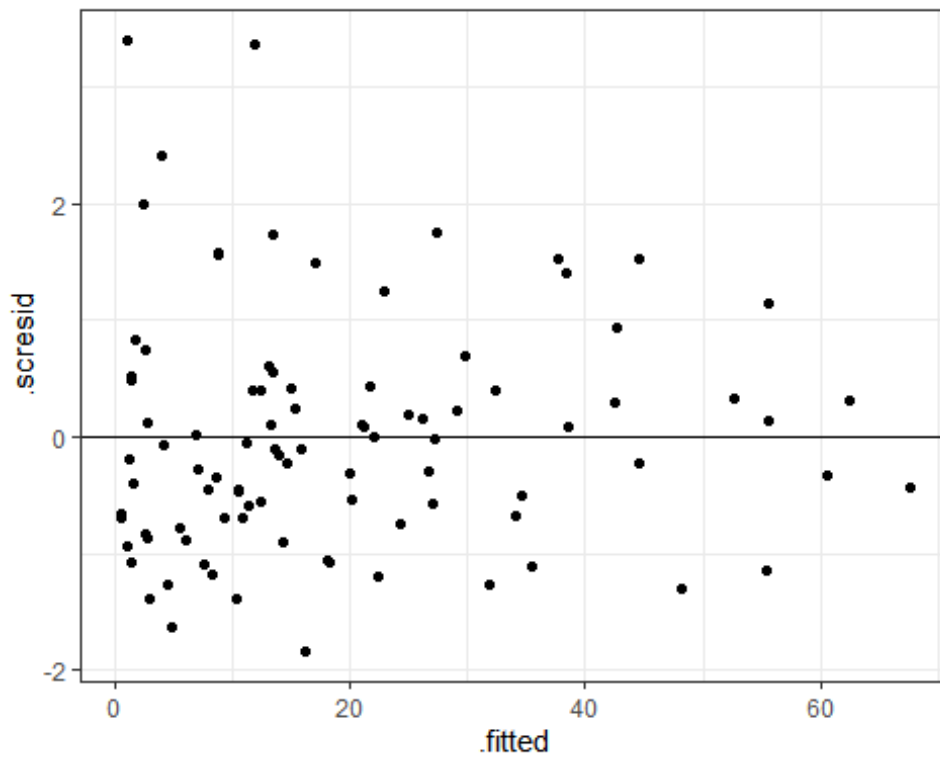
```
##      df      AIC
## Mod17   20 659.0071
## Mod17.1 18 656.6881
```

#Модель Mod17.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M17.1:без пропусков/с пропусками
model_diag(Mod17.1)



```
model_diag3(Mod17.1)
```



```
Mod18=glmer.nb(CountJ451~code+TSPMax+(1+TSPMax|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
```



```

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

Mod18.1=glmer.nb(CountJ451~code+TSPMax+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

summary(Mod18.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(50.0713) ( log )
## Formula: CountJ451 ~ code + TSPMax + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    366.2    411.8   -165.1    330.2        75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8190 -0.6500 -0.2048  0.5488  3.4365
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 1.41      1.187
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -8.12080    0.60875 -13.340 < 2e-16 ***
## code2        0.73123    0.34194  2.138 0.032479 *
## code3        0.17594    0.36106  0.487 0.626062
## code4        1.48530    0.40662  3.653 0.000259 ***
## code5        0.01517    0.44233  0.034 0.972634
## code6        0.70182    0.48059  1.460 0.144202
## code7        0.21411    0.33017  0.648 0.516674
## code8        1.19102    0.48166  2.473 0.013408 *
## code9        1.03707    0.23149  4.480 7.47e-06 ***
## code10       -0.05768    0.22535 -0.256 0.797994
## code11       0.23988    0.29875  0.803 0.422010
## code12       -0.23072    0.25072 -0.920 0.357451
## code13       -0.07956    0.30454 -0.261 0.793898
## code14       -0.93564    0.37779 -2.477 0.013262 *
## code15       -0.05093    0.31563 -0.161 0.871810
## TSPMax       0.90551    0.61825  1.465 0.143023
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

overdisp_fun(Mod18.1)

##      chisq      ratio      rdf      p
## 85.0088436  1.1334512 75.0000000 0.2011994

getME(Mod18.1, 'glmer.nb.theta')

## [1] 50.07133

icc(Mod18.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##   Adjusted ICC: 0.789
##   Conditional ICC: 0.652

## Модель М4.1 (распределение Пуассона) лучше подходит для данных!!! См выше

Mod19=glmer.nb(CountJ450~code+TSPMax+(1+TSPMax|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular

isSingular(Mod19)

## [1] TRUE

Mod19.1=glmer.nb(CountJ450~code+TSPMax+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
isSingular(Mod19.1)

## [1] FALSE

summary(Mod19.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: Negative Binomial(5.9728) ( log )
##   Formula: CountJ450 ~ code + TSPMax + (1 | year) + offset(lPop)
##   Data: PMdata
##   Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid

```

```

##      655.0      700.6     -309.5      619.0          75
##
## Scaled residuals:
##      Min        1Q    Median        3Q        Max
## -1.8892 -0.7186 -0.1845  0.5083  3.3071
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year   (Intercept) 0.317    0.563
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.24519    0.40672 -12.896 < 2e-16 ***
## code2        0.78506    0.33581  2.338 0.019397 *
## code3        0.10751    0.29540  0.364 0.715896
## code4        1.13393    0.32079  3.535 0.000408 ***
## code5        0.56829    0.28628  1.985 0.047138 *
## code6       -0.17886    0.38858 -0.460 0.645312
## code7        0.32714    0.32560  1.005 0.315033
## code8        0.17357    0.39054  0.444 0.656718
## code9        0.76935    0.24526  3.137 0.001708 **
## code10       -0.02670    0.24178 -0.110 0.912070
## code11       -0.16317    0.26778 -0.609 0.542304
## code12        0.26634    0.24566  1.084 0.278281
## code13        0.20575    0.25096  0.820 0.412314
## code14       -0.34029    0.26091 -1.304 0.192152
## code15       -0.06338    0.29135 -0.218 0.827791
## TSPMax       -0.65611    0.49568 -1.324 0.185616
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod19.1)

##      chisq      ratio      rdf      p
## 91.33095028  1.21774600 75.00000000 0.09665109

getME(Mod19.1, 'glmer.nb.theta')

## [1] 5.972811

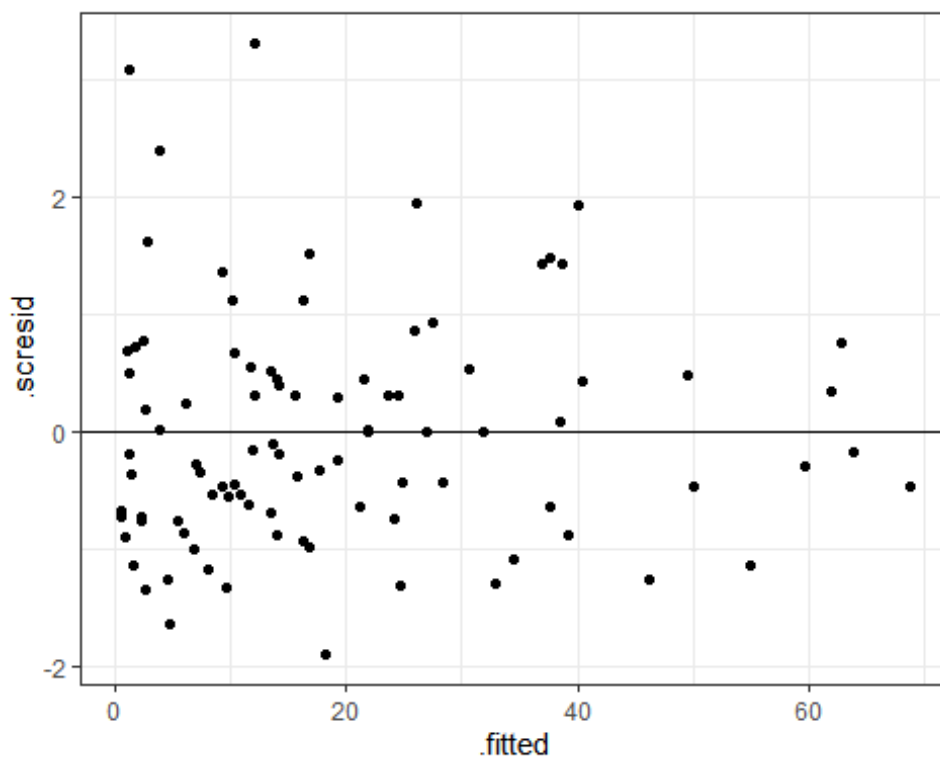
icc(Mod19.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.612
##      Conditional ICC: 0.433

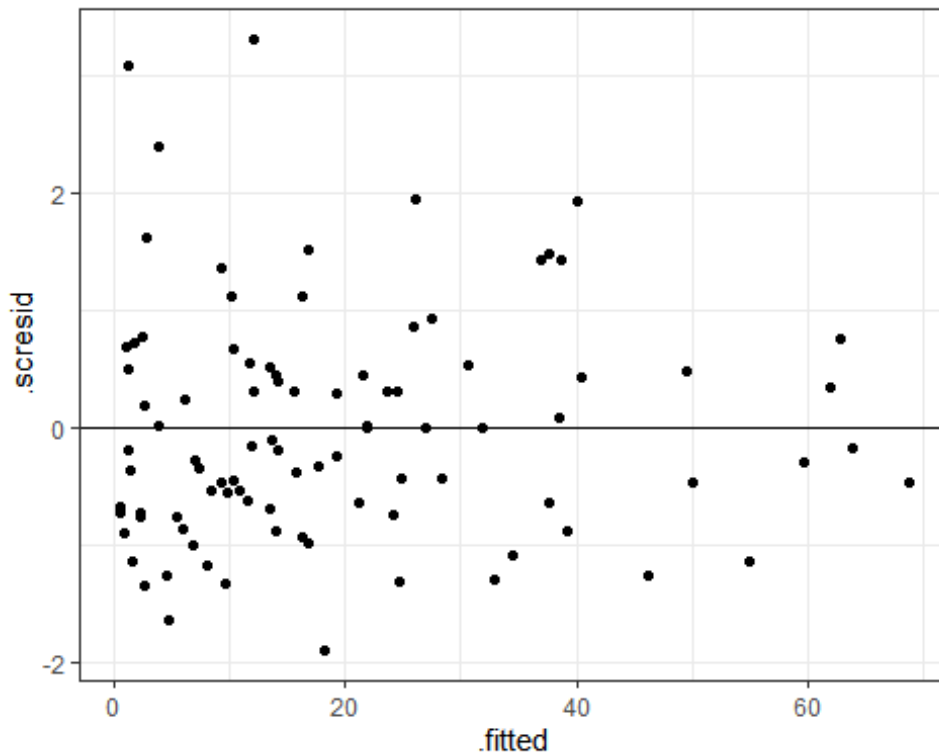
```

#Модель Mod19.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M19.1:без пропусков/с пропусками
`model_diag(Mod19.1)`



`model_diag3(Mod19.1)`



```
Mod20=glmer.nb(CountJ451~code+PM.2.5Avr+(1+PM.2.5Avr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular
isSingular(Mod20)

## [1] TRUE

Mod20.1=glmer.nb(CountJ451~code+PM.2.5Avr+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
isSingular(Mod20.1)

## [1] FALSE

summary(Mod20.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(19.6023) ( log )
## Formula: CountJ451 ~ code + PM.2.5Avr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    368.1    413.6   -166.0    332.1       75
##
## Scaled residuals:
```

```

##      Min      1Q  Median      3Q      Max
## -1.8647 -0.6358 -0.2273  0.5765  2.8252
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.465      1.21
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.55314    0.55771 -13.543 < 2e-16 ***
## code2        0.54771    0.38274  1.431 0.152426
## code3        0.06267    0.39018  0.161 0.872397
## code4        1.17819    0.41356  2.849 0.004387 **
## code5       -0.23514    0.46025 -0.511 0.609421
## code6        0.64270    0.50717  1.267 0.205070
## code7        0.16332    0.37001  0.441 0.658921
## code8        1.08519    0.51652  2.101 0.035645 *
## code9        0.98033    0.26030  3.766 0.000166 ***
## code10       0.03946    0.24759  0.159 0.873376
## code11       0.17930    0.31850  0.563 0.573472
## code12      -0.25926    0.27406 -0.946 0.344155
## code13      -0.11596    0.32736 -0.354 0.723178
## code14      -1.00525    0.40426 -2.487 0.012895 *
## code15      -0.26680    0.33264 -0.802 0.422514
## PM.2.5Avr   -1.16733    7.88532 -0.148 0.882312
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod20.1)

##      chisq      ratio      rdf      p
## 77.0165327  1.0268871 75.0000000 0.4138925

getME(Mod20.1, 'glmer.nb.theta')

## [1] 19.60231

icc(Mod20.1)

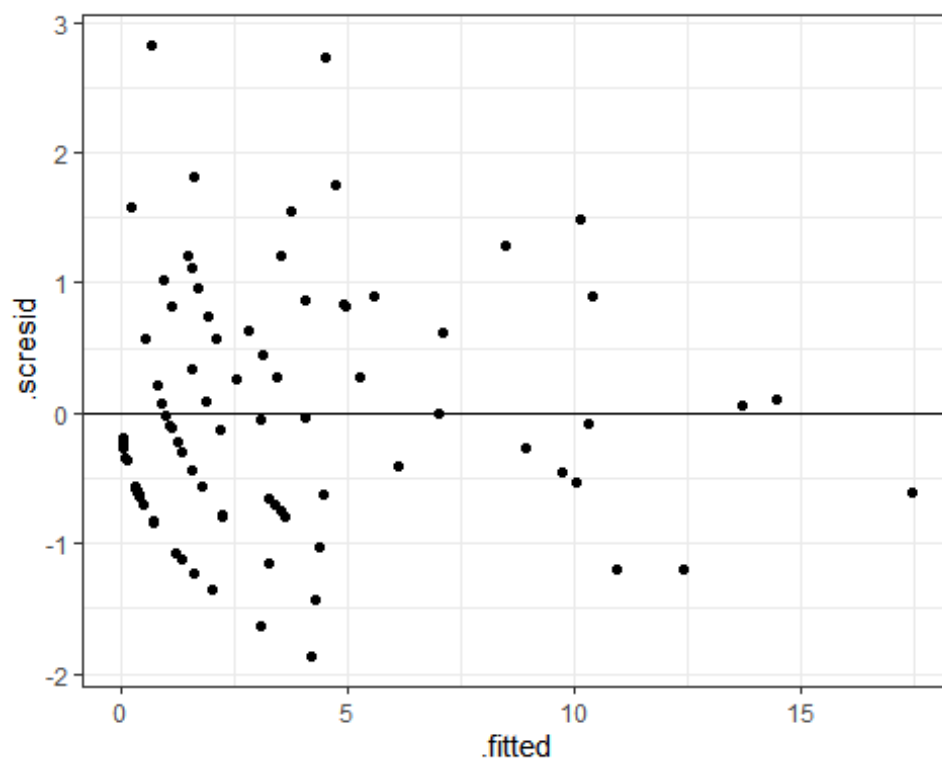
## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.786
##      Conditional ICC: 0.657

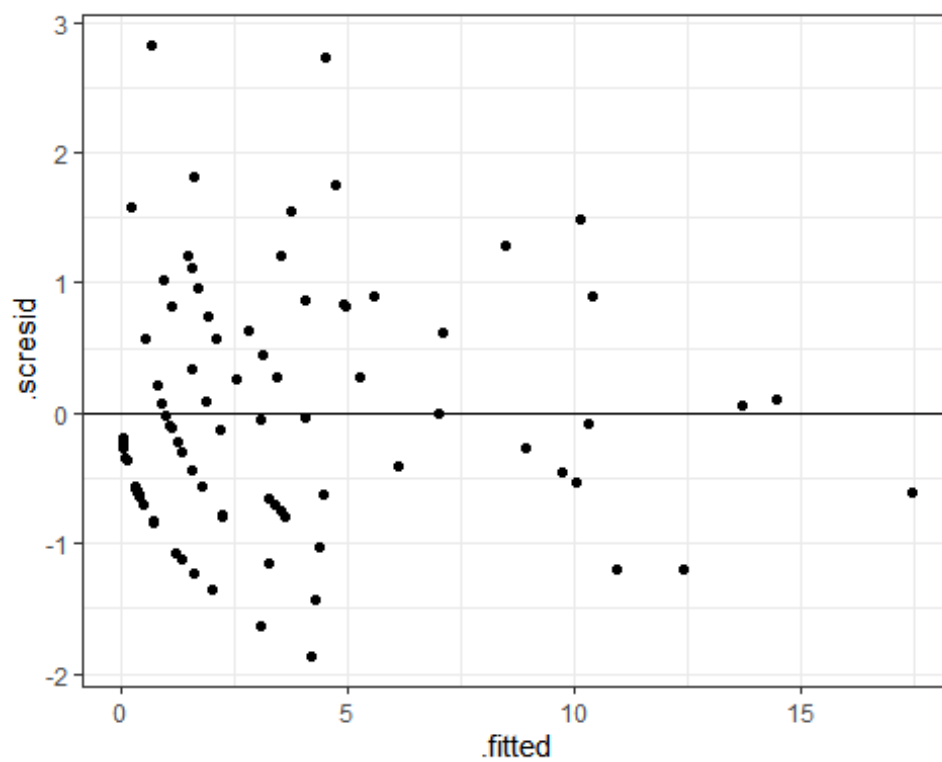
```

#Сравнить M8.1 и Mod20.1 по остаткам! Модель 8.1 лучше

#Диагностика модели (анализ остатков) - M20.1:без пропусков/с пропусками
model_diag(Mod20.1)



model_diag3(Mod20.1)



```

Mod21=glmer.nb(CountJ450~code+PM.2.5Avr+(1+PM.2.5Avr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
summary(Mod21)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.3162) ( log )
## Formula: CountJ450 ~ code + PM.2.5Avr + (1 + PM.2.5Avr | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    656.2    706.9   -308.1    616.2      73
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9575 -0.6816 -0.0949  0.4028  3.3070
##
## Random effects:
## Groups Name             Variance Std.Dev. Corr
## year  (Intercept)    0.06618  0.2573
##      PM.2.5Avr    135.06249 11.6216  1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.62937    0.25588 -22.000 < 2e-16 ***
## code2        0.95774    0.31504  3.040 0.002365 **
## code3        0.27121    0.28899  0.938 0.348007
## code4        1.44477    0.29841  4.842 1.29e-06 ***
## code5        0.77708    0.28470  2.729 0.006345 **
## code6       -0.06718    0.39163 -0.172 0.863810
## code7        0.41211    0.31947  1.290 0.197062
## code8        0.35735    0.40226  0.888 0.374350
## code9        0.85401    0.24180  3.532 0.000413 ***
## code10       -0.05042    0.23733 -0.212 0.831753
## code11       -0.09200    0.26321 -0.350 0.726695
## code12        0.43123    0.25140  1.715 0.086286 .
## code13        0.20918    0.24792  0.844 0.398816
## code14       -0.25399    0.26364 -0.963 0.335341
## code15        0.14835    0.28433  0.522 0.601840
## PM.2.5Avr    -0.31076    7.56490 -0.041 0.967233
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod21)

```



```

##          chisq          ratio          rdf          p
## 91.46639232  1.25296428 73.00000000  0.07081334

Mod21.1=glmer.nb(CountJ450~code+PM.2.5Avr+(1|year)+offset(lPop),PMdata,
                  control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod21.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.9536) ( log )
## Formula: CountJ450 ~ code + PM.2.5Avr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##          AIC          BIC    logLik deviance df.resid
##      655.8       701.4   -309.9    619.8        75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8486 -0.7147 -0.0668  0.4877  3.2423
##
## Random effects:
## Groups Name          Variance Std.Dev.
## year   (Intercept) 0.2783   0.5275
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.479621   0.309496 -17.705 < 2e-16 ***
## code2        0.849550   0.327345  2.595  0.00945 **
## code3        0.148474   0.291775  0.509  0.61085
## code4        1.248794   0.292877  4.264 2.01e-05 ***
## code5        0.616951   0.282062  2.187  0.02872 *
## code6       -0.179450   0.392841 -0.457  0.64781
## code7        0.322935   0.327008  0.988  0.32337
## code8        0.149966   0.397984  0.377  0.70631
## code9        0.784679   0.244839  3.205  0.00135 **
## code10       -0.055013   0.240935 -0.228  0.81939
## code11       -0.130147   0.265894 -0.489  0.62451
## code12       0.306665   0.245469  1.249  0.21155
## code13       0.215218   0.250443  0.859  0.39015
## code14      -0.343989   0.264577 -1.300  0.19355
## code15       0.004301   0.280662  0.015  0.98777
## PM.2.5Avr   -5.675487   5.660857 -1.003  0.31606
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

```

```
overdisp_fun(Mod21.1)
```

```
##          chisq          ratio          rdf          p  
## 93.63779171  1.24850389 75.00000000  0.07149466
```

```
getME(Mod20.1, 'glmer.nb.theta')
```

```
## [1] 19.60231
```

```
icc(Mod21.1)
```

```
## # Intraclass Correlation Coefficient
```

```
##
```

```
##      Adjusted ICC: 0.580
```

```
##      Conditional ICC: 0.405
```

```
AIC(Mod21, Mod21.1)
```

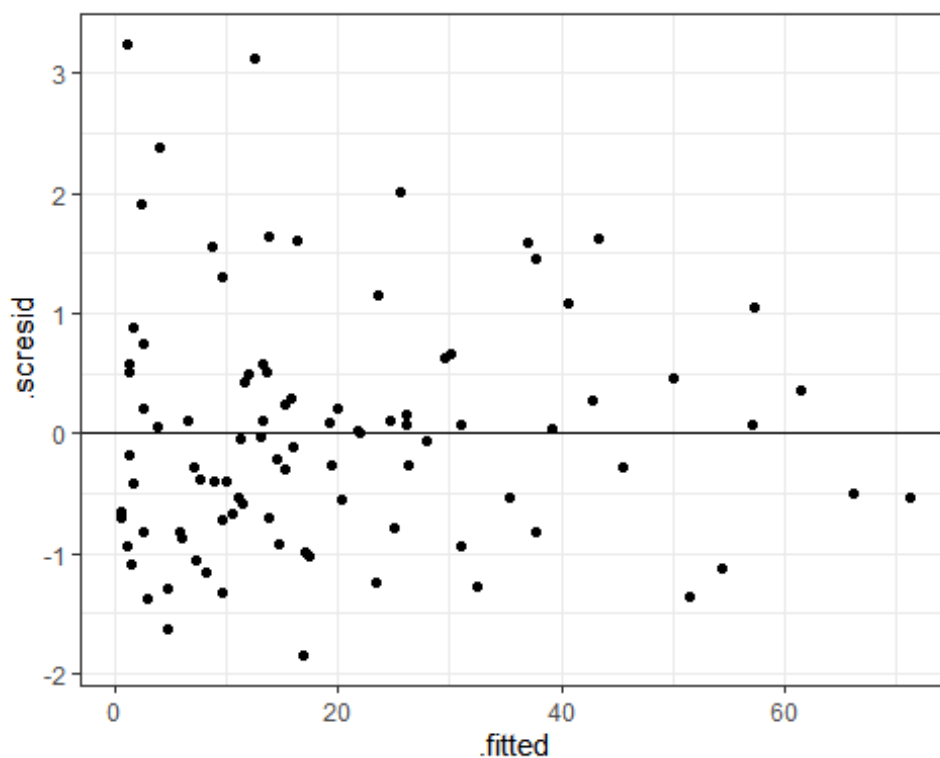
```
##          df          AIC
```

```
## Mod21      20 656.2015
```

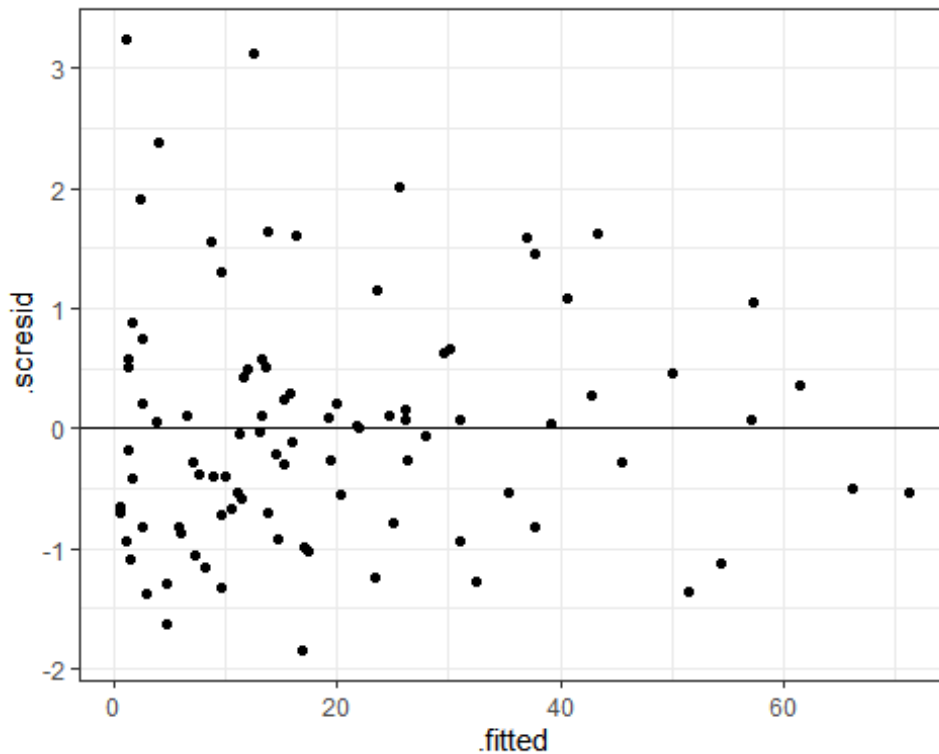
```
## Mod21.1    18 655.8026
```

#Модель Mod21.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M21.1:без пропусков/с пропусками
`model_diag(Mod21.1)`



```
model_diag3(Mod21.1)
```



```
Mod22=glmer.nb(CountJ451~code+PM.10Avr+(1+PM.10Avr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

## boundary (singular) fit: see ?isSingular

isSingular(Mod22)

## [1] TRUE

Mod22.1=glmer.nb(CountJ451~code+PM.10Avr+(1|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

summary(Mod22.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(56.1415) ( log )
## Formula: CountJ451 ~ code + PM.10Avr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##  367.0    412.6  -165.5    331.0        75
```

```

##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9824 -0.6893 -0.2320  0.5942  2.7584
##
## Random effects:
##   Groups Name            Variance Std.Dev.
##   year   (Intercept) 1.624      1.274
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.090137   0.656052 -10.807  < 2e-16 ***
## code2        0.359322   0.386137   0.931  0.352083
## code3       -0.186720   0.408862  -0.457  0.647900
## code4        0.868618   0.453175   1.917  0.055271 .
## code5       -0.492309   0.474259  -1.038  0.299242
## code6        0.488868   0.499775   0.978  0.327987
## code7        0.114656   0.335792   0.341  0.732765
## code8        0.856728   0.521167   1.644  0.100204
## code9        0.914349   0.236586   3.865  0.000111 ***
## code10       0.009151   0.220068   0.042  0.966833
## code11       0.115951   0.303360   0.382  0.702296
## code12      -0.368318   0.260845  -1.412  0.157944
## code13      -0.162159   0.307754  -0.527  0.598255
## code14      -1.147889   0.394663  -2.909  0.003631 **
## code15      -0.450363   0.324461  -1.388  0.165126
## PM.10Avr    -5.476960   4.481288  -1.222  0.221638
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod22.1)

##      chisq      ratio      rdf      p
## 82.0082815  1.0934438 75.0000000 0.2711398

getME(Mod22.1, 'glmer.nb.theta')

## [1] 56.14147

icc(Mod22.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##   unreliable.

## # Intraclass Correlation Coefficient
##

```

```

## Adjusted ICC: 0.812
## Conditional ICC: 0.682

#Модель М9.1 (распределение Пуассона) лучше подходит для данных!!! См выше

Mod23=glmer.nb(CountJ450~code+PM.10Avr+(1+PM.10Avr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
summary(Mod23)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.2689) ( log )
## Formula: CountJ450 ~ code + PM.10Avr + (1 + PM.10Avr | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    658.6    709.3   -309.3    618.6      73
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.9487 -0.7403 -0.0858  0.4283  3.3372
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept)  0.08625  0.2937
##         PM.10Avr    17.06634  4.1311  1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.40376    0.40985 -13.185 < 2e-16 ***
## code2        0.81323    0.35187  2.311 0.020823 *
## code3        0.14108    0.32468  0.435 0.663909
## code4        1.26830    0.34026  3.727 0.000193 ***
## code5        0.62068    0.31489  1.971 0.048709 *
## code6       -0.18307    0.40432 -0.453 0.650697
## code7        0.34265    0.32383  1.058 0.289997
## code8        0.19022    0.41631  0.457 0.647731
## code9        0.79308    0.24450  3.244 0.001180 **
## code10       -0.06497    0.23729 -0.274 0.784237
## code11       -0.11417    0.26625 -0.429 0.668074
## code12        0.27729    0.24883  1.114 0.265126
## code13        0.19135    0.24943  0.767 0.442978
## code14       -0.33232    0.27040 -1.229 0.219066
## code15        0.03469    0.29125  0.119 0.905199
## PM.10Avr     -3.25242    4.33113 -0.751 0.452689
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

overdisp_fun(Mod23)

##          chisq          ratio          rdf          p
## 91.86713365  1.25845389 73.00000000  0.06703104

Mod23.1=glmer.nb(CountJ450~code+PM.10Avr+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod23.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.0067) ( log )
## Formula: CountJ450 ~ code + PM.10Avr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##          AIC          BIC    logLik deviance df.resid
##      656.6       702.2   -310.3    620.6         75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8446 -0.7006 -0.1126  0.4831  3.2836
##
## Random effects:
## Groups Name          Variance Std.Dev.
## year   (Intercept) 0.317    0.563
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.48661    0.45200 -12.138 < 2e-16 ***
## code2        0.85552    0.36115  2.369 0.017842 *
## code3        0.14931    0.33107  0.451 0.651992
## code4        1.26527    0.34774  3.639 0.000274 ***
## code5        0.64286    0.32136  2.000 0.045451 *
## code6       -0.15820    0.40748 -0.388 0.697845
## code7        0.33796    0.32907  1.027 0.304415
## code8        0.17523    0.42193  0.415 0.677913
## code9        0.79185    0.24796  3.193 0.001406 **
## code10       -0.05796    0.24011 -0.241 0.809246
## code11       -0.14479    0.26786 -0.541 0.588816
## code12        0.26465    0.25296  1.046 0.295461
## code13        0.21467    0.25127  0.854 0.392909
## code14       -0.32615    0.27379 -1.191 0.233554
## code15        0.03347    0.29577  0.113 0.909893
## PM.10Avr     -1.72775    3.97840 -0.434 0.664083
```

```

## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod23.1)

##          chisq          ratio          rdf          p
## 94.65375833  1.26205011 75.00000000  0.06225876

getME(Mod23.1, 'glmer.nb.theta')

## [1] 6.006718

icc(Mod23.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.613
##      Conditional ICC: 0.438

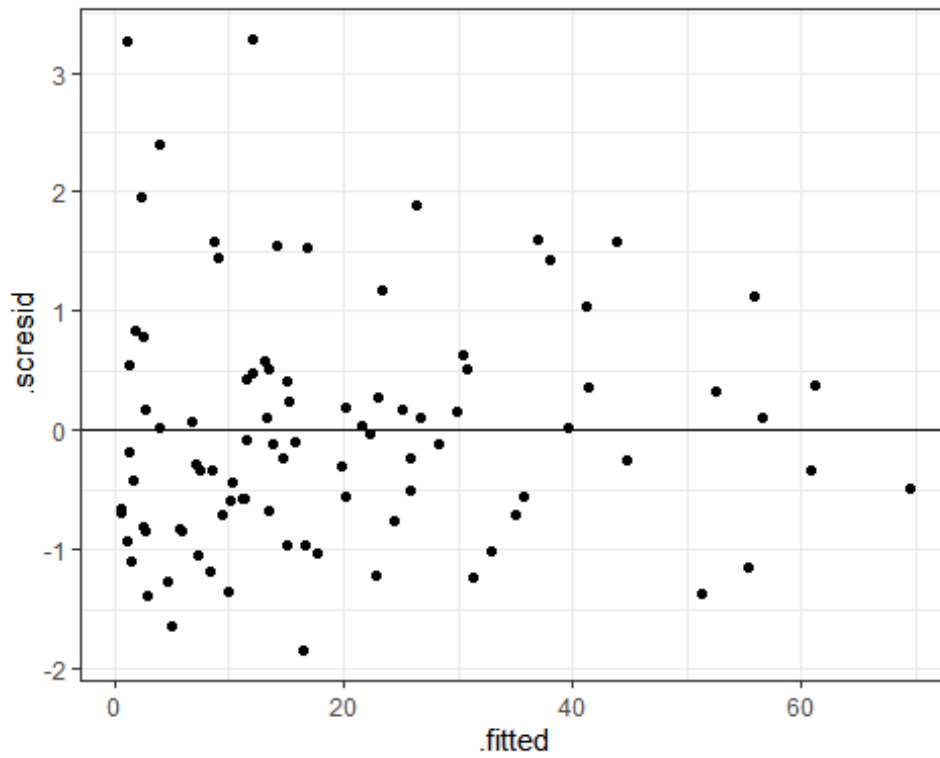
AIC(Mod23, Mod23.1)

##          df          AIC
## Mod23    20 658.6000
## Mod23.1  18 656.5898

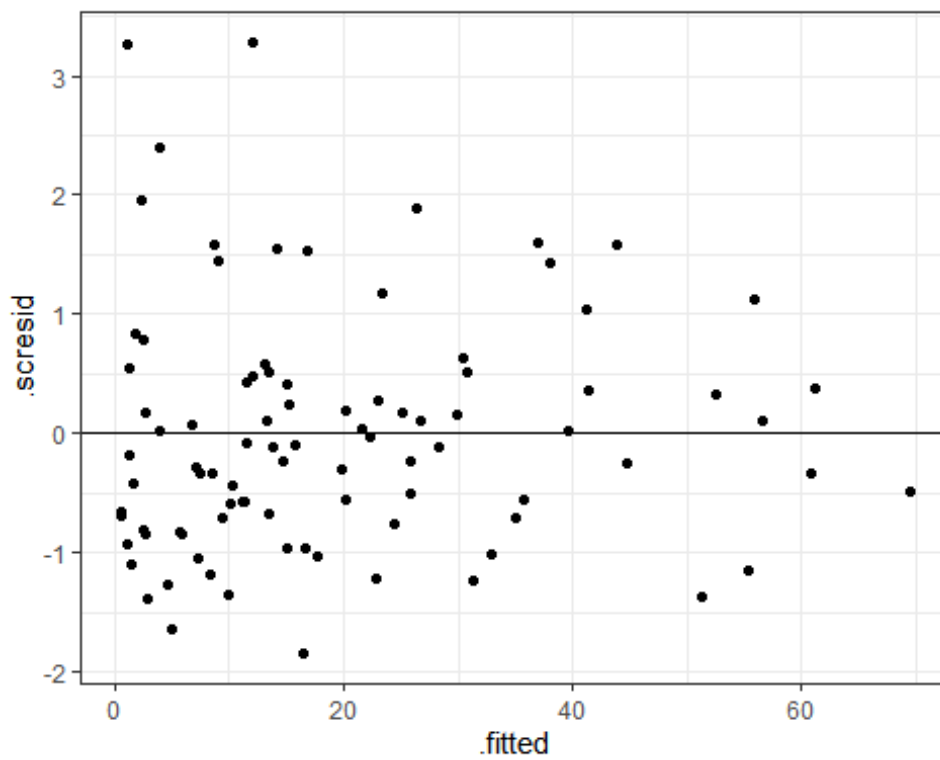
#Модель Mod23.1 (отрицательное биномиальное распределение) лучше подходит для да
нных!!!

#Диагностика модели (анализ остатков) - M23.1:без пропусков/с пропусками
model_diag(Mod23.1)

```



```
model_diag3(Mod23.1)
```



```
Mod24=glmer.nb(CountJ451~code+TSPAver+(1+TSPAver|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
```



```

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

## boundary (singular) fit: see ?isSingular
isSingular(Mod24)

## [1] TRUE

Mod24.1=glmer.nb(CountJ451~code+TSPAvr+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))

## Warning in theta.ml(Y, mu, weights = object@resp$weights, limit = limit, :
## iteration limit reached

summary(Mod24.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(51.205) ( log )
## Formula: CountJ451 ~ code + TSPAvr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    367.6    413.2   -165.8    331.6        75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.0052 -0.6716 -0.2393  0.5998  2.7970
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 1.662    1.289
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -7.13347    0.71422  -9.988  < 2e-16 ***
## code2        0.41527    0.38890   1.068  0.28560
## code3       -0.11198    0.40336  -0.278  0.78131
## code4        0.98617    0.43136   2.286  0.02224 *
## code5       -0.37804    0.45385  -0.833  0.40487
## code6        0.56102    0.49234   1.140  0.25449
## code7        0.16259    0.33258   0.489  0.62492
## code8        0.96969    0.50302   1.928  0.05389 .
## code9        0.93975    0.23630   3.977 6.98e-05 ***
## code10       0.04058    0.22526   0.180  0.85705
## code11       0.15404    0.30072   0.512  0.60848
## code12      -0.34709    0.26406  -1.314  0.18870
## code13      -0.13521    0.30672  -0.441  0.65934
## code14      -1.10086    0.39251  -2.805  0.00504 **
## code15      -0.39298    0.32123  -1.223  0.22120

```

```

## TSPAvr      -2.85570    3.07274  -0.929  0.35270
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod24.1)

##      chisq      ratio      rdf      p
## 82.4269636  1.0990262 75.0000000  0.2605965

getME(Mod24.1, 'glmer.nb.theta')

## [1] 51.20499

icc(Mod24.1)

## Warning: mu of 2.3 is too close to zero, estimate of random effect variances
may be
##  unreliable.

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.815
##      Conditional ICC: 0.685

#Модель M10.1 (распределение Пуассона) лучше подходит для данных!!! См выше

Mod25=glmer.nb(CountJ450~code+TSPAvr+(1+TSPAvr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
summary(Mod25)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.4075) ( log )
## Formula: CountJ450 ~ code + TSPAvr + (1 + TSPAvr | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    659.5    710.1   -309.7    619.5      73
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -1.8722 -0.6896 -0.1752  0.4765  3.3297
##
## Random effects:
## Groups Name      Variance Std.Dev. Corr
## year  (Intercept) 0.4086  0.6392

```

```

##          TSPAver      10.4521  3.2330   -0.50
## Number of obs: 93, groups:  year, 7
##
## Fixed effects:
##          Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.37562    0.51075 -10.525 < 2e-16 ***
## code2        0.80145    0.36205   2.214 0.026856 *
## code3        0.17636    0.31789   0.555 0.579038
## code4        1.23420    0.32808   3.762 0.000169 ***
## code5        0.64275    0.29130   2.206 0.027352 *
## code6       -0.19169    0.39655  -0.483 0.628806
## code7        0.33880    0.32292   1.049 0.294099
## code8        0.16240    0.40281   0.403 0.686819
## code9        0.80297    0.24228   3.314 0.000919 ***
## code10       -0.08329    0.24062  -0.346 0.729245
## code11       -0.14667    0.26418  -0.555 0.578753
## code12        0.29788    0.24551   1.213 0.225005
## code13        0.20841    0.24706   0.844 0.398921
## code14       -0.34116    0.26525  -1.286 0.198392
## code15        0.02316    0.28299   0.082 0.934763
## TSPAver     -1.80112    2.93640  -0.613 0.539629
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod25)

##          chisq          ratio          rdf          p
## 89.90814956  1.23161849 73.00000000  0.08721531

Mod25.1=glmer.nb(CountJ450~code+TSPAver+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod25.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.0014) ( log )
## Formula: CountJ450 ~ code + TSPAver + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##          AIC          BIC    logLik deviance df.resid
##      656.5      702.1   -310.2    620.5         75
##
## Scaled residuals:
##      Min        1Q    Median        3Q        Max
## -1.8427 -0.6953 -0.1356  0.4791  3.3996
##

```

```

## Random effects:
##   Groups Name      Variance Std.Dev.
##   year  (Intercept) 0.3301   0.5745
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.41772    0.50376 -10.754 < 2e-16 ***
## code2        0.83944    0.35985   2.333 0.019661 *
## code3        0.14328    0.32029   0.447 0.654637
## code4        1.25894    0.33002   3.815 0.000136 ***
## code5        0.65012    0.29506   2.203 0.027570 *
## code6       -0.15821    0.39943  -0.396 0.692038
## code7        0.34245    0.32590   1.051 0.293360
## code8        0.18466    0.40384   0.457 0.647481
## code9        0.79136    0.24621   3.214 0.001308 **
## code10       -0.04505    0.24090  -0.187 0.851656
## code11       -0.13711    0.26581  -0.516 0.605980
## code12        0.27026    0.24808   1.089 0.275985
## code13        0.21742    0.25021   0.869 0.384889
## code14       -0.32650    0.26839  -1.217 0.223779
## code15        0.02966    0.28891   0.103 0.918235
## TSPAvr       -1.41605    2.64593  -0.535 0.592526
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##   vcov(x)           if you need it

overdisp_fun(Mod25.1)

##          chisq          ratio          rdf          p
## 94.47583653  1.25967782 75.00000000  0.06380075

getME(Mod25.1, 'glmer.nb.theta')

## [1] 6.001368

icc(Mod25.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.623
##      Conditional ICC: 0.448

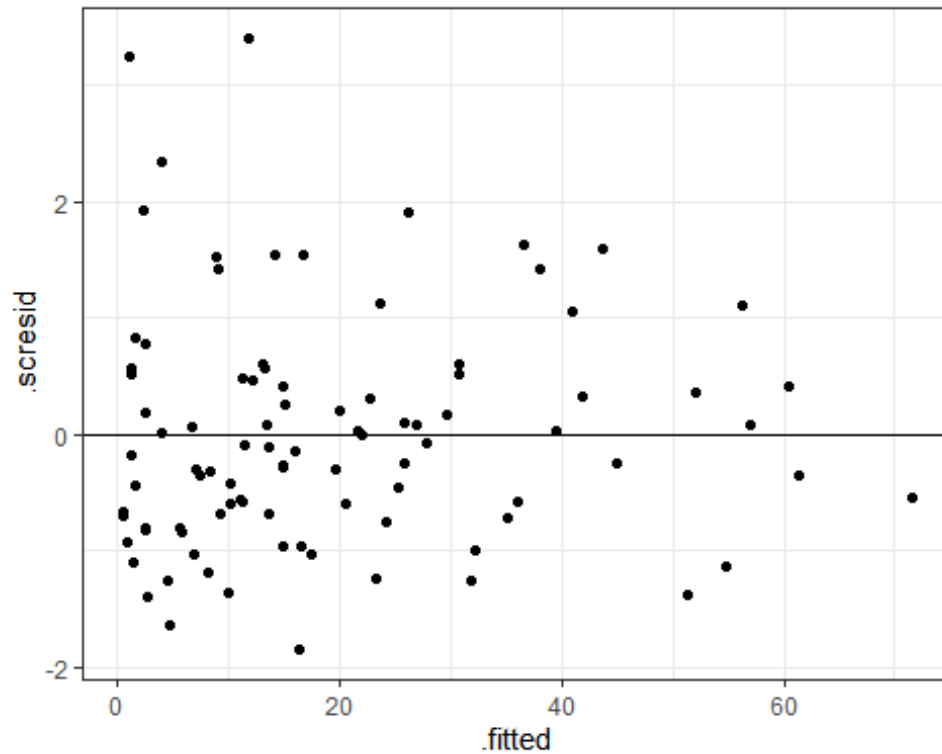
AIC(Mod25, Mod25.1)

##          df          AIC
## Mod25     20 659.4655
## Mod25.1   18 656.4911

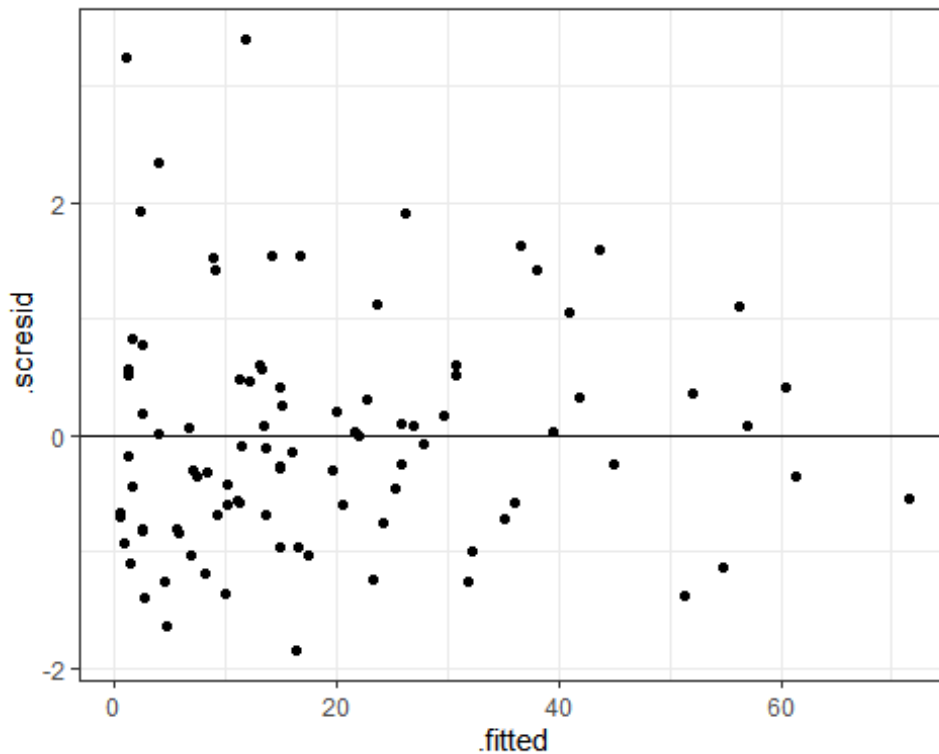
```

#Модель Mod25.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M25.1:без пропусков/с пропусками
`model_diag(Mod25.1)`



`model_diag3(Mod25.1)`



```
Mod26=glmer.nb(CountJ450~code+TBPLogMax+(1+TBPLogMax|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## Warning in optTheta(g1, interval = interval, tol = tol, verbose = verbose, :
## unable to evaluate scaled gradient

## Warning in optTheta(g1, interval = interval, tol = tol, verbose = verbose, :
## Model failed to converge: degenerate Hessian with 2 negative eigenvalues

summary(Mod26)

## Warning in vcov.merMod(object, use.hessian = use.hessian): variance-covarianc
e matrix computed from finite-difference Hessian is
## not positive definite or contains NA values: falling back to var-cov estimate
d from RX

## Warning in vcov.merMod(object, correlation = correlation, sigm = sig): varian
ce-covariance matrix computed from finite-difference Hessian is
## not positive definite or contains NA values: falling back to var-cov estimate
d from RX

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.5326) ( log )
## Formula: CountJ450 ~ code + TBPLogMax + (1 + TBPLogMax | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##          AIC          BIC    logLik deviance df.resid
```

```

##      633.4      683.1     -296.7      593.4         69
##
## Scaled residuals:
##      Min        1Q    Median        3Q        Max
## -1.9222 -0.6775 -0.1051  0.3966  3.3456
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept)  0.1395  0.3735
##         TBPLogMax   111.6030 10.5642  1.00
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.937942   0.304236 -19.518 < 2e-16 ***
## code2        0.985529   0.311613  3.163  0.00156 **
## code3        0.314837   0.283090  1.112  0.26608
## code4        1.531652   0.287644  5.325 1.01e-07 ***
## code5        0.878441   0.277884  3.161  0.00157 **
## code6       -0.055056   0.376059  -0.146  0.88360
## code7        0.434960   0.309969  1.403  0.16055
## code8        0.287456   0.421626  0.682  0.49538
## code9        0.747394   0.250222  2.987  0.00282 **
## code10      -0.071260   0.233091  -0.306  0.75982
## code11       0.007267   0.271126  0.027  0.97862
## code12       0.413298   0.247884  1.667  0.09545 .
## code13       0.251790   0.247101  1.019  0.30821
## code14      -0.241390   0.251806  -0.959  0.33774
## code15       0.209014   0.272558  0.767  0.44316
## TBPLogMax   13.866201  10.773164  1.287  0.19806
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

## optimizer (bobyqa) convergence code: 0 (OK)
## unable to evaluate scaled gradient
## Model failed to converge: degenerate Hessian with 2 negative eigenvalues
overdisp_fun(Mod26)

##      chisq      ratio      rdf      p
## 91.66385890  1.32846172 69.00000000  0.03542153

Mod26.1=glmer.nb(CountJ450~code+TBPLogMax+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod26.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]

```

```

## Family: Negative Binomial(6.1941) ( log )
## Formula: CountJ450 ~ code + TBPLogMax + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    630.7    675.5   -297.3    594.7      71
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.7929 -0.6576 -0.1502  0.3513  3.2512
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.2967   0.5447
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.970574   0.345854 -17.263 < 2e-16 ***
## code2        0.991440   0.315375   3.144  0.00167 **
## code3        0.341147   0.285782   1.194  0.23258
## code4        1.524085   0.289767   5.260 1.44e-07 ***
## code5        0.907604   0.285733   3.176  0.00149 **
## code6       -0.035139   0.385774  -0.091  0.92742
## code7        0.383913   0.319170   1.203  0.22904
## code8        0.284829   0.422447   0.674  0.50016
## code9        0.742396   0.252935   2.935  0.00333 **
## code10       -0.087118   0.237847  -0.366  0.71416
## code11       0.006453   0.275497   0.023  0.98131
## code12       0.438247   0.260422   1.683  0.09241 .
## code13       0.266201   0.247996   1.073  0.28309
## code14      -0.240569   0.256286  -0.939  0.34790
## code15       0.206240   0.274990   0.750  0.45326
## TBPLogMax    15.196356  10.231833   1.485  0.13749
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod26.1)

##      chisq      ratio      rdf      p
## 92.33949611  1.30055628 71.00000000 0.04530816

getME(Mod26.1, 'glmer.nb.theta')

## [1] 6.194079

icc(Mod26.1)

```



```
## # Intraclass Correlation Coefficient
```

```
##
```

```
##      Adjusted ICC: 0.602
```

```
##      Conditional ICC: 0.425
```

```
AIC(Mod26, Mod26.1)
```

```
##      df      AIC
```

```
## Mod26    20 633.3535
```

```
## Mod26.1  18 630.6590
```

#Модель Mod26.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Присутствует сверхдисперсия

```
Mod27=glmer.nb(CountJ450~code+PLogMax+(1+PLogMax|year)+offset(lPop),PMdata,  
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2  
00000)))
```

```
summary(Mod27)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
```

```
## Approximation) [glmerMod]
```

```
## Family: Negative Binomial(6.4856) ( log )
```

```
## Formula: CountJ450 ~ code + PLogMax + (1 + PLogMax | year) + offset(lPop)
```

```
## Data: PMdata
```

```
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
```

```
##
```

```
##      AIC      BIC    logLik deviance df.resid
```

```
##    633.2    683.0   -296.6    593.2      69
```

```
##
```

```
## Scaled residuals:
```

```
##      Min      1Q   Median      3Q      Max
```

```
## -1.9157 -0.6800 -0.1048  0.4041  3.3475
```

```
##
```

```
## Random effects:
```

```
## Groups Name      Variance Std.Dev. Corr
```

```
## year  (Intercept)  0.1461  0.3822
```

```
##      PLogMax      318.6610 17.8511  1.00
```

```
## Number of obs: 89, groups: year, 7
```

```
##
```

```
## Fixed effects:
```

```
##      Estimate Std. Error z value Pr(>|z|)
```

```
## (Intercept) -5.94274    0.30871 -19.250 < 2e-16 ***
```

```
## code2        0.98517    0.30990   3.179  0.00148 **
```

```
## code3        0.31551    0.28151   1.121  0.26238
```

```
## code4        1.55204    0.28896   5.371 7.82e-08 ***
```

```
## code5        0.88065    0.28377   3.103  0.00191 **
```

```
## code6       -0.05198    0.38397  -0.135  0.89232
```

```
## code7        0.43585    0.31893   1.367  0.17175
```

```
## code8        0.29320    0.41896   0.700  0.48404
```

```
## code9        0.74463    0.24946   2.985  0.00284 **
```

```
## code10      -0.06537    0.23430  -0.279  0.78026
```

```

## code11      0.00689      0.27145      0.025      0.97975
## code12      0.41559      0.25512      1.629      0.10331
## code13      0.25494      0.24483      1.041      0.29774
## code14     -0.23982      0.25331     -0.947      0.34376
## code15      0.20941      0.26989      0.776      0.43781
## PLogMax     24.29738     19.46393      1.248      0.21191
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod27)

##          chisq          ratio          rdf          p
## 91.10276385  1.32032991 69.00000000  0.03862897

Mod27.1=glmer.nb(CountJ450~code+PLogMax+(1|year)+offset(lPop),PMdata,
                  control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod27.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.2148) ( log )
## Formula: CountJ450 ~ code + PLogMax + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##   630.6    675.4   -297.3    594.6       71
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.7838 -0.6572 -0.1443  0.3526  3.2660
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.2949   0.5431
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.974243   0.344751 -17.329 < 2e-16 ***
## code2        0.995301   0.315244  3.157  0.00159 **
## code3        0.345610   0.285970  1.209  0.22683
## code4        1.543778   0.293922  5.252  1.5e-07 ***
## code5        0.918756   0.288153  3.188  0.00143 **
## code6       -0.030959   0.385862 -0.080  0.93605
## code7        0.382861   0.318617  1.202  0.22951
## code8        0.290899   0.422714  0.688  0.49135

```

```

## code9      0.742072  0.252544  2.938  0.00330 **
## code10     -0.081087  0.237180 -0.342  0.73244
## code11      0.006774  0.275076  0.025  0.98035
## code12      0.439272  0.260002  1.689  0.09112 .
## code13      0.271131  0.247951  1.093  0.27418
## code14     -0.239321  0.255973 -0.935  0.34982
## code15      0.208522  0.274681  0.759  0.44777
## PLogMax    26.982170 17.897455  1.508  0.13166
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod27.1)

##      chisq      ratio      rdf      p
## 92.72927669  1.30604615 71.00000000 0.04275244

getME(Mod27.1, 'glmer.nb.theta')

## [1] 6.214826

icc(Mod27.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.601
##      Conditional ICC: 0.424

AIC(Mod27, Mod27.1)

##      df      AIC
## Mod27    20 633.2403
## Mod27.1  18 630.5963

#Модель Mod27.1 (отрицательное биномиальное распределение) лучше подходит для да
нных!!!
#Присутствует сверхдисперсия

Mod28=glmer.nb(CountJ450~code+TBlogMax+(1+TBlogMax|year)+offset(lPop), PMdata,
               control=glmerControl(optimizer='bobyqa', optCtrl = list(maxfun = 2
00000)))
summary(Mod28)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(6.455) ( log )
## Formula: CountJ450 ~ code + TBlogMax + (1 + TBlogMax | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC  logLik deviance df.resid

```

```

##      633.6      683.4     -296.8      593.6          69
##
## Scaled residuals:
##      Min        1Q    Median        3Q        Max
## -1.9243 -0.6763 -0.0978  0.3365  3.3176
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year  (Intercept)    0.1246  0.353
##         TBLogMax      723.5197 26.898   1.00
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.8964402  0.3074426 -19.179 < 2e-16 ***
## code2        0.9764889  0.3095905   3.154  0.00161 **
## code3        0.2999527  0.2809811   1.068  0.28574
## code4        1.4866770  0.2803263   5.303 1.14e-07 ***
## code5        0.8545068  0.2777164   3.077  0.00209 **
## code6       -0.0672138  0.3835976  -0.175  0.86091
## code7        0.4318769  0.3194903   1.352  0.17645
## code8        0.2663131  0.4178204   0.637  0.52387
## code9        0.7455209  0.2498233   2.984  0.00284 **
## code10       -0.0753392  0.2358144  -0.319  0.74936
## code11       -0.0004142  0.2717467  -0.002  0.99878
## code12        0.3975001  0.2560541   1.552  0.12057
## code13        0.2417504  0.2446246   0.988  0.32303
## code14       -0.2505109  0.2536128  -0.988  0.32327
## code15        0.1931651  0.2699925   0.715  0.47433
## TBLogMax     27.3778425 27.0491805   1.012  0.31147
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod28)

##      chisq      ratio      rdf      p
## 91.07959292  1.31999410 69.00000000  0.03876664

Mod28.1=glmer.nb(CountJ450~code+TBLogMax+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod28.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##   Family: Negative Binomial(6.1544) ( log )
## Formula: CountJ450 ~ code + TBLogMax + (1 | year) + offset(lPop)
##   Data: PMdata

```

```

## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    630.8    675.6   -297.4    594.8      71
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8054 -0.6689 -0.1255  0.3395  3.2278
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year   (Intercept) 0.299    0.5468
## Number of obs: 89, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.952544   0.345890 -17.209  < 2e-16 ***
## code2        0.984109   0.315790   3.116  0.00183 **
## code3        0.331596   0.285597   1.161  0.24562
## code4        1.493063   0.284738   5.244 1.57e-07 ***
## code5        0.886278   0.282313   3.139  0.00169 **
## code6       -0.043179   0.385727  -0.112  0.91087
## code7        0.384422   0.320198   1.201  0.22992
## code8        0.272426   0.422119   0.645  0.51868
## code9        0.741437   0.253645   2.923  0.00347 **
## code10       -0.093212   0.238999  -0.390  0.69653
## code11       0.003645   0.276184   0.013  0.98947
## code12       0.433181   0.261012   1.660  0.09699 .
## code13       0.258537   0.248253   1.041  0.29768
## code14      -0.244121   0.256840  -0.950  0.34187
## code15       0.198466   0.275379   0.721  0.47109
## TBLogMax    33.361493  23.637417   1.411  0.15813
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod28.1)

##      chisq      ratio      rdf      p
## 91.76267357  1.29243202 71.00000000 0.04932845

getME(Mod28.1, 'glmer.nb.theta')

## [1] 6.154447

icc(Mod28.1)

## # Intraclass Correlation Coefficient
##

```

```
## Adjusted ICC: 0.603
## Conditional ICC: 0.427
```

```
AIC(Mod28, Mod28.1)
```

```
##      df      AIC
## Mod28  20 633.5776
## Mod28.1 18 630.8277
```

#Модель Mod28.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!
#Присутствует сверхдисперсия

```
Mod29=glmer.nb(CountJ450~code+TBPLogAvr+(1+TBPLogAvr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
summary(Mod29)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.3352) ( log )
## Formula: CountJ450 ~ code + TBPLogAvr + (1 + TBPLogAvr | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    705.6    757.3   -332.8    665.6        78
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.6624 -0.7634 -0.1621  0.6031  3.0615
##
## Random effects:
##  Groups Name      Variance Std.Dev. Corr
##  year  (Intercept)  0.0633  0.2516
##       TBPLogAvr   4227.5794 65.0198  1.00
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.28088    0.31640 -16.690 < 2e-16 ***
## code2        0.40664    0.30307  1.342 0.179683
## code3       -0.05381    0.28705 -0.187 0.851309
## code4        1.17872    0.33228  3.547 0.000389 ***
## code5        0.52525    0.31239  1.681 0.092688 .
## code6       -0.23595    0.40493 -0.583 0.560096
## code7        0.23537    0.27684  0.850 0.395203
## code8        0.14263    0.41492  0.344 0.731022
## code9        0.80027    0.25867  3.094 0.001976 **
## code10       -0.03842    0.25443 -0.151 0.879978
## code11       -0.01916    0.28993 -0.066 0.947304
## code12        0.35273    0.27057  1.304 0.192351
```

```

## code13      0.19585    0.26365    0.743 0.457590
## code14     -0.36025    0.27627   -1.304 0.192241
## code15     -0.01068    0.29595   -0.036 0.971222
## TBPLogAvr  -68.12151   48.34109   -1.409 0.158781
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

overdisp_fun(Mod29)

##          chisq          ratio          rdf          p
## 98.93046422  1.26833928 78.00000000  0.05501997

Mod29.1=glmer.nb(CountJ450~code+TBPLogAvr+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod29.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.0911) ( log )
## Formula: CountJ450 ~ code + TBPLogAvr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##  703.6    750.1   -333.8   667.6      80
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.5924 -0.7573 -0.1975  0.5681  3.0049
##
## Random effects:
## Groups Name          Variance Std.Dev.
## year   (Intercept) 0.2878    0.5365
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.483243    0.314589 -17.430 < 2e-16 ***
## code2        0.456644    0.303491  1.505  0.13242
## code3       -0.006934    0.280935  -0.025  0.98031
## code4        1.242788    0.312511  3.977 6.99e-05 ***
## code5        0.625179    0.294349  2.124  0.03368 *
## code6       -0.171649    0.401001  -0.428  0.66861
## code7        0.289139    0.274997  1.051  0.29306
## code8        0.178304    0.406145  0.439  0.66065
## code9        0.790326    0.261270  3.025  0.00249 **
## code10      -0.059956    0.257339  -0.233  0.81577

```

```

## code11      -0.046867    0.291640   -0.161    0.87233
## code12      0.347695    0.272451    1.276    0.20189
## code13      0.226387    0.265837    0.852    0.39444
## code14     -0.321084    0.274592   -1.169    0.24228
## code15      0.034004    0.290766    0.117    0.90690
## TBPLogAvr  -20.120763   21.132953   -0.952    0.34104
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod29.1)

##          chisq          ratio          rdf          p
## 99.23638927  1.24045487 80.00000000  0.07141834

getME(Mod29.1, 'glmer.nb.theta')

## [1] 5.09108

icc(Mod29.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.562
##      Conditional ICC: 0.409

AIC(Mod29, Mod29.1)

##          df          AIC
## Mod29     20 705.6212
## Mod29.1   18 703.6073

#Модель Mod29.1 (отрицательное биномиальное распределение) лучше подходит для да
нных!!!

Mod30=glmer.nb(CountJ450~code+PLogAvr+(1+PLogAvr|year)+offset(lPop), PMdata,
               control=glmerControl(optimizer='bobyqa', optCtrl = list(maxfun = 2
00000)))

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
: Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
: Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

## Warning in optTheta(g1, interval = interval, tol = tol, verbose = verbose, :
Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

```



```

summary(Mod30)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.3133) ( log )
## Formula: CountJ450 ~ code + PLogAvr + (1 + PLogAvr | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    705.9    757.6   -333.0    665.9      78
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.6636 -0.7592 -0.1546  0.5943  2.9630
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept) 6.491e-02  0.2548
##         PLogAvr    1.337e+04 115.6481 1.00
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.340e+00 3.110e-01 -17.171 < 2e-16 ***
## code2        4.242e-01 3.068e-01  1.383 0.166781
## code3       -3.245e-02 2.871e-01  -0.113 0.909986
## code4        1.218e+00 3.341e-01  3.644 0.000268 ***
## code5        5.552e-01 3.153e-01  1.761 0.078266 .
## code6       -2.122e-01 4.057e-01  -0.523 0.600895
## code7        2.545e-01 2.783e-01  0.915 0.360309
## code8        1.678e-01 4.179e-01  0.401 0.688072
## code9        8.021e-01 2.600e-01  3.085 0.002034 **
## code10      -4.483e-02 2.550e-01  -0.176 0.860469
## code11      -1.564e-02 2.904e-01  -0.054 0.957061
## code12       3.462e-01 2.707e-01  1.279 0.200893
## code13       1.920e-01 2.645e-01  0.726 0.467878
## code14      -3.453e-01 2.773e-01  -1.245 0.212998
## code15       5.357e-03 2.971e-01  0.018 0.985615
## PLogAvr     -1.042e+02 9.032e+01  -1.153 0.248823
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

## optimizer (bobyqa) convergence code: 0 (OK)
## Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

overdisp_fun(Mod30)

```

```

##      chisq      ratio      rdf      p
## 98.671426  1.265018 78.000000  0.057021

Mod30.1=glmer.nb(CountJ450~code+PLogAvr+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod30.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.0623) ( log )
## Formula: CountJ450 ~ code + PLogAvr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    703.8    750.4   -333.9    667.8      80
##
## Scaled residuals:
##      Min      1Q  Median      3Q      Max
## -1.5922 -0.7566 -0.1853  0.5640  3.0035
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.2821   0.5311
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.513220   0.306617 -17.981 < 2e-16 ***
## code2        0.465796   0.304752  1.528  0.12640
## code3        0.006773   0.279887  0.024  0.98069
## code4        1.263608   0.310042  4.076 4.59e-05 ***
## code5        0.641244   0.293253  2.187  0.02877 *
## code6       -0.158976   0.400483 -0.397  0.69140
## code7        0.296178   0.275434  1.075  0.28223
## code8        0.188973   0.406551  0.465  0.64206
## code9        0.791900   0.262293  3.019  0.00253 **
## code10       -0.062546   0.257920 -0.243  0.80839
## code11       -0.043500   0.292098 -0.149  0.88161
## code12       0.347584   0.273095  1.273  0.20310
## code13       0.226237   0.266521  0.849  0.39596
## code14      -0.315442   0.274926 -1.147  0.25123
## code15       0.043384   0.290806  0.149  0.88141
## PLogAvr     -28.525002  34.110828 -0.836  0.40302
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)      if you need it

```

```

overdisp_fun(Mod30.1)

##          chisq          ratio          rdf          p
## 99.10571863  1.23882148 80.00000000  0.07264772

getME(Mod30.1, 'glmer.nb.theta')

## [1] 5.062314

icc(Mod30.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.556
##      Conditional ICC: 0.406

AIC(Mod30, Mod30.1)

##          df          AIC
## Mod30      20 705.9397
## Mod30.1    18 703.8212

#Модель Mod30.1 (отрицательное биномиальное распределение) лучше подходит для да
нных!!!

Mod31=glmer.nb(CountJ450~code+TBLogAvr+(1+TBLogAvr|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## Warning in checkConv(attr(opt, "derivs"), opt$par, ctrl = control$checkConv,
: Model is nearly unidentifiable: large eigenvalue ratio
## - Rescale variables?

## Warning in optTheta(g1, interval = interval, tol = tol, verbose = verbose, :
## unable to evaluate scaled gradient

## Warning in optTheta(g1, interval = interval, tol = tol, verbose = verbose, :
## Model failed to converge: degenerate Hessian with 1 negative eigenvalues

summary(Mod31)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.3342) ( log )
## Formula: CountJ450 ~ code + TBLogAvr + (1 + TBLogAvr | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##          AIC          BIC    logLik deviance df.resid
##      705.5      757.2    -332.8    665.5         78
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.6561 -0.7682 -0.1740  0.6067  3.1816

```

```
##
## Random effects:
##   Groups Name      Variance Std.Dev. Corr
##   year  (Intercept) 6.903e-02  0.2627
##           TBLLogAvr  1.972e+04 140.4239 1.00
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -5.23094    0.32720 -15.987  < 2e-16 ***
## code2         0.40062    0.30115   1.330   0.18342
## code3        -0.07091    0.28911  -0.245   0.80626
## code4         1.14691    0.33550   3.419   0.00063 ***
## code5         0.50509    0.31195   1.619   0.10542
## code6        -0.25283    0.40513  -0.624   0.53258
## code7         0.22392    0.27583   0.812   0.41690
## code8         0.12659    0.41347   0.306   0.75947
## code9         0.80346    0.25816   3.112   0.00186 **
## code10        -0.03359    0.25419  -0.132   0.89486
## code11        -0.02516    0.29029  -0.087   0.93092
## code12         0.36228    0.27136   1.335   0.18186
## code13         0.20230    0.26317   0.769   0.44205
## code14        -0.36981    0.27564  -1.342   0.17971
## code15        -0.02043    0.29535  -0.069   0.94484
## TBLLogAvr    -171.43796  108.06779  -1.586   0.11265
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

## optimizer (bobyqa) convergence code: 0 (OK)
## unable to evaluate scaled gradient
## Model failed to converge: degenerate Hessian with 1 negative eigenvalues

overdisp_fun(Mod31)

##      chisq      ratio      rdf      p
## 99.25930077  1.27255514 78.00000000  0.05256484

Mod31.1=glmer.nb(CountJ450~code+TBLLogAvr+(1|year)+offset(lPop),PMdata,
                  control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod31.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(5.1294) ( log )
## Formula: CountJ450 ~ code + TBLLogAvr + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
```

```

##      AIC      BIC   logLik deviance df.resid
##    703.4    749.9   -333.7   667.4      80
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.5905 -0.7663 -0.2075  0.5679  3.0101
##
## Random effects:
##   Groups Name      Variance Std.Dev.
##   year   (Intercept) 0.2966   0.5447
## Number of obs: 98, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.44376    0.32542 -16.728 < 2e-16 ***
## code2        0.45100    0.30086   1.499 0.133860
## code3       -0.02400    0.28213  -0.085 0.932218
## code4        1.21760    0.31524   3.862 0.000112 ***
## code5        0.60668    0.29523   2.055 0.039885 *
## code6       -0.18701    0.40152  -0.466 0.641395
## code7        0.28265    0.27403   1.031 0.302316
## code8        0.16957    0.40484   0.419 0.675318
## code9        0.79229    0.25970   3.051 0.002283 **
## code10      -0.05661    0.25658  -0.221 0.825368
## code11      -0.05163    0.29108  -0.177 0.859208
## code12       0.34791    0.27164   1.281 0.200263
## code13       0.22575    0.26496   0.852 0.394202
## code14      -0.32746    0.27405  -1.195 0.232128
## code15       0.02449    0.29024   0.084 0.932758
## TBLogAvr    -58.47888   54.02602  -1.082 0.279066
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##   vcov(x)           if you need it

overdisp_fun(Mod31.1)

##      chisq      ratio      rdf      p
## 99.34783225  1.24184790 80.00000000 0.07038335

getME(Mod31.1, 'glmer.nb.theta')

## [1] 5.129358

icc(Mod31.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.571
##      Conditional ICC: 0.414

```

```

AIC(Mod31, Mod31.1)

##           df           AIC
## Mod31      20 705.5314
## Mod31.1    18 703.3561

#Модель Mod31.1 (отрицательное биномиальное распределение) лучше подходит для да
нных!!!

Mod32=glmer.nb(CountJ458~code+PM.2.5Max+(1+PM.2.5Max|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular

summary(Mod32)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(4.6976) ( log )
## Formula: CountJ458 ~ code + PM.2.5Max + (1 + PM.2.5Max | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##           AIC           BIC    logLik deviance df.resid
##          730.7          781.4   -345.4    690.7         73
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.78341 -0.78201 -0.07477  0.55477  2.62290
##
## Random effects:
## Groups Name             Variance Std.Dev. Corr
## year   (Intercept) 0.01895  0.1377
##        PM.2.5Max  0.18528  0.4304   1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.20336    0.27884 -18.661 < 2e-16 ***
## code2        0.15529    0.34973  0.444  0.65703
## code3        0.21103    0.30218  0.698  0.48495
## code4        1.29655    0.31229  4.152  3.3e-05 ***
## code5        0.57992    0.29672  1.954  0.05065 .
## code6       -0.18424    0.36539 -0.504  0.61409
## code7        0.76582    0.33770  2.268  0.02335 *
## code8        0.18586    0.37776  0.492  0.62271
## code9        0.83074    0.26209  3.170  0.00153 **
## code10       -0.06006    0.26025 -0.231  0.81750
## code11       0.28884    0.26899  1.074  0.28292
## code12       0.64087    0.25976  2.467  0.01362 *
## code13       0.26673    0.26731  0.998  0.31835
## code14      -0.44043    0.27309 -1.613  0.10680

```

```

## code15      -0.29721    0.30262  -0.982   0.32604
## PM.2.5Max    0.05727    1.18539   0.048   0.96146
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

## optimizer (bobyqa) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular

overdisp_fun(Mod32)

##      chisq      ratio      rdf      p
## 90.23750204  1.23613016 73.00000000  0.08351518

Mod32.1=glmer.nb(CountJ458~code+PM.2.5Max+(1|year)+offset(lPop),PMdata,
                  control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod32.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(4.6725) ( log )
## Formula: CountJ458 ~ code + PM.2.5Max + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    726.9    772.5   -345.4    690.9        75
##
## Scaled residuals:
##      Min      1Q   Median      3Q      Max
## -1.77822 -0.78784 -0.07942  0.58154  2.58243
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.03919  0.198
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##      Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.19375    0.28269 -18.372 < 2e-16 ***
## code2        0.15708    0.35038  0.448  0.65393
## code3        0.21300    0.30339  0.702  0.48264
## code4        1.27682    0.30871  4.136 3.54e-05 ***
## code5        0.58445    0.29732  1.966  0.04933 *
## code6       -0.17937    0.36568 -0.491  0.62377
## code7        0.76497    0.33810  2.263  0.02366 *
## code8        0.18486    0.37842  0.489  0.62520
## code9        0.82329    0.26209  3.141  0.00168 **
## code10       -0.05631    0.26057 -0.216  0.82890

```

```
## code11      0.29469      0.26919      1.095      0.27364
## code12      0.63943      0.26053      2.454      0.01411 *
## code13      0.27685      0.26711      1.036      0.29999
## code14     -0.43717      0.27347     -1.599      0.10991
## code15     -0.29600      0.30329     -0.976      0.32909
## PM.2.5Max  -0.01350      1.15184     -0.012      0.99065
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it
```

```
overdisp_fun(Mod32.1)
```

```
##      chisq      ratio      rdf      p
## 90.3089497  1.2041193 75.0000000  0.1098358
```

```
getME(Mod32.1, 'glmer.nb.theta')
```

```
## [1] 4.672498
```

```
icc(Mod32.1)
```

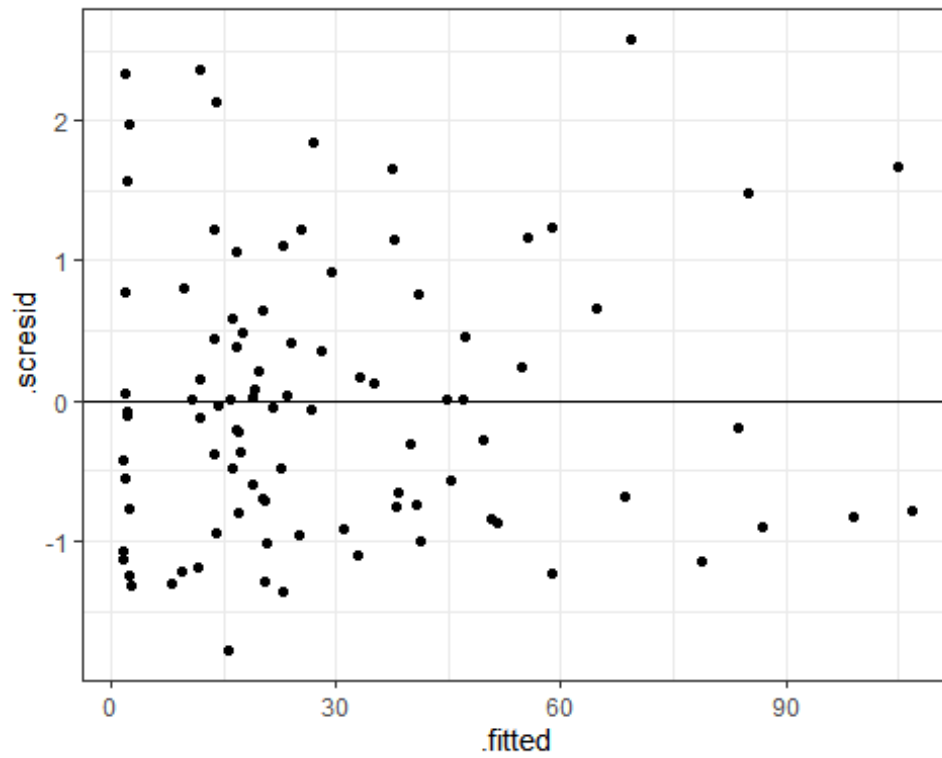
```
## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.150
##      Conditional ICC: 0.083
```

```
AIC(Mod32, Mod32.1)
```

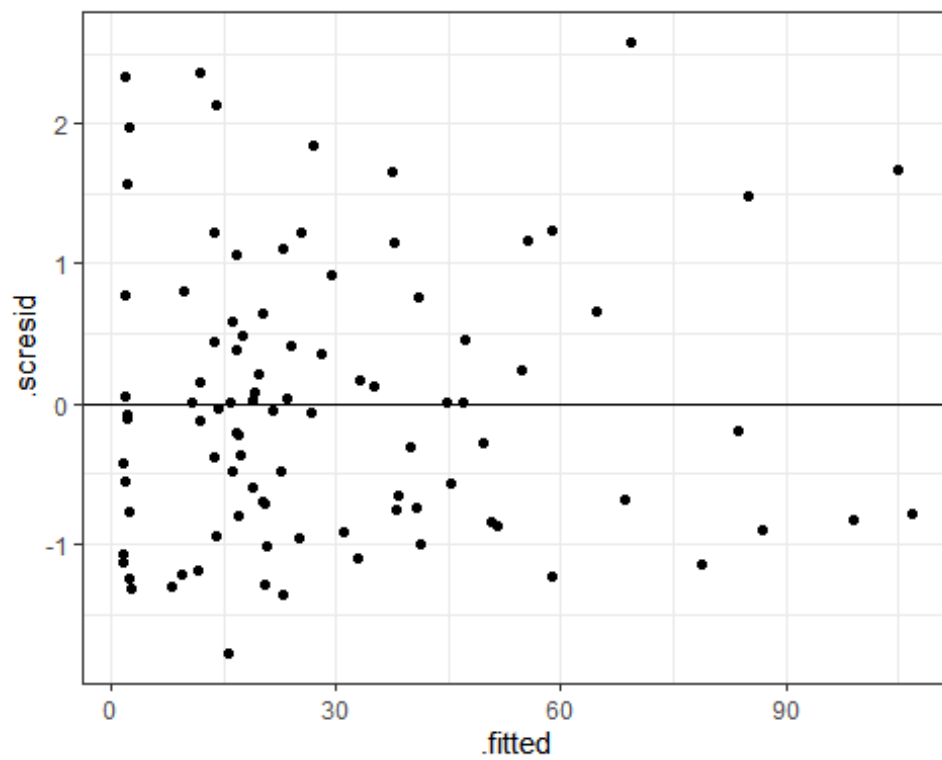
```
##      df      AIC
## Mod32   20 730.7022
## Mod32.1 18 726.8730
```

#Модель Mod32.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M32.1:без пропусков/с пропусками
model_diag(Mod32.1)



```
model_diag3(Mod32.1)
```



```
Mod33=glmer.nb(CountJ458~code+PM.10Max+(1+PM.10Max|year)+offset(lPop),PMdata,
                control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))
summary(Mod33)
```

```

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(4.8144) ( log )
## Formula: CountJ458 ~ code + PM.10Max + (1 + PM.10Max | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC    logLik deviance df.resid
##    729.7    780.3   -344.8    689.7      73
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.80288 -0.77742 -0.07149  0.58094  2.81125
##
## Random effects:
##   Groups Name            Variance Std.Dev. Corr
##   year  (Intercept) 8.358e-05 0.009142
##         PM.10Max   5.608e-01 0.748867 -1.00
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.22561    0.30223  -17.290 < 2e-16 ***
## code2        0.14393    0.35479   0.406  0.68498
## code3        0.20945    0.30724   0.682  0.49543
## code4        1.32387    0.31683   4.178 2.93e-05 ***
## code5        0.58505    0.29566   1.979  0.04784 *
## code6       -0.19863    0.36750  -0.540  0.58886
## code7        0.77502    0.33597   2.307  0.02107 *
## code8        0.19718    0.38285   0.515  0.60653
## code9        0.82504    0.26162   3.154  0.00161 **
## code10       -0.06681    0.25771  -0.259  0.79543
## code11       0.30451    0.26633   1.143  0.25289
## code12       0.62101    0.26014   2.387  0.01698 *
## code13       0.23759    0.26679   0.891  0.37317
## code14      -0.44381    0.27196  -1.632  0.10270
## code15      -0.29341    0.30154  -0.973  0.33054
## PM.10Max     0.09743    0.75620   0.129  0.89748
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod33)

##      chisq      ratio      rdf      p
## 90.47125558  1.23933227 73.00000000 0.08096666

Mod33.1=glmer.nb(CountJ458~code+PM.10Max+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =

```

```

200000)))
summary(Mod33.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(4.6769) ( log )
## Formula: CountJ458 ~ code + PM.10Max + (1 | year) + offset(1Pop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##    726.8    772.4   -345.4    690.8       75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.77977 -0.77652 -0.07748  0.53503  2.65504
##
## Random effects:
## Groups Name      Variance Std.Dev.
## year  (Intercept) 0.03831  0.1957
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) -5.25837    0.31689 -16.594 < 2e-16 ***
## code2        0.17710    0.35456  0.499  0.61743
## code3        0.23725    0.31037  0.764  0.44462
## code4        1.31733    0.31980  4.119 3.8e-05 ***
## code5        0.61588    0.29747  2.070 0.03842 *
## code6       -0.16321    0.36830 -0.443 0.65766
## code7        0.77228    0.33870  2.280 0.02260 *
## code8        0.21337    0.38544  0.554 0.57987
## code9        0.83195    0.26404  3.151 0.00163 **
## code10       -0.06089    0.26030 -0.234 0.81504
## code11       0.29498    0.26850  1.099 0.27193
## code12       0.64579    0.26158  2.469 0.01356 *
## code13       0.28216    0.26685  1.057 0.29033
## code14      -0.42755    0.27459 -1.557 0.11946
## code15      -0.27343    0.30606 -0.893 0.37164
## PM.10Max     0.18269    0.72582  0.252 0.80127
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)          if you need it

overdisp_fun(Mod33.1)

##      chisq      ratio      rdf      p
## 90.5696332  1.2075951 75.0000000 0.1063466

```

```
getME(Mod33.1, 'glmer.nb.theta')
```

```
## [1] 4.67689
```

```
icc(Mod33.1)
```

```
## # Intraclass Correlation Coefficient
```

```
##
```

```
##      Adjusted ICC: 0.147
```

```
##      Conditional ICC: 0.081
```

```
AIC(Mod33, Mod33.1)
```

```
##      df      AIC
```

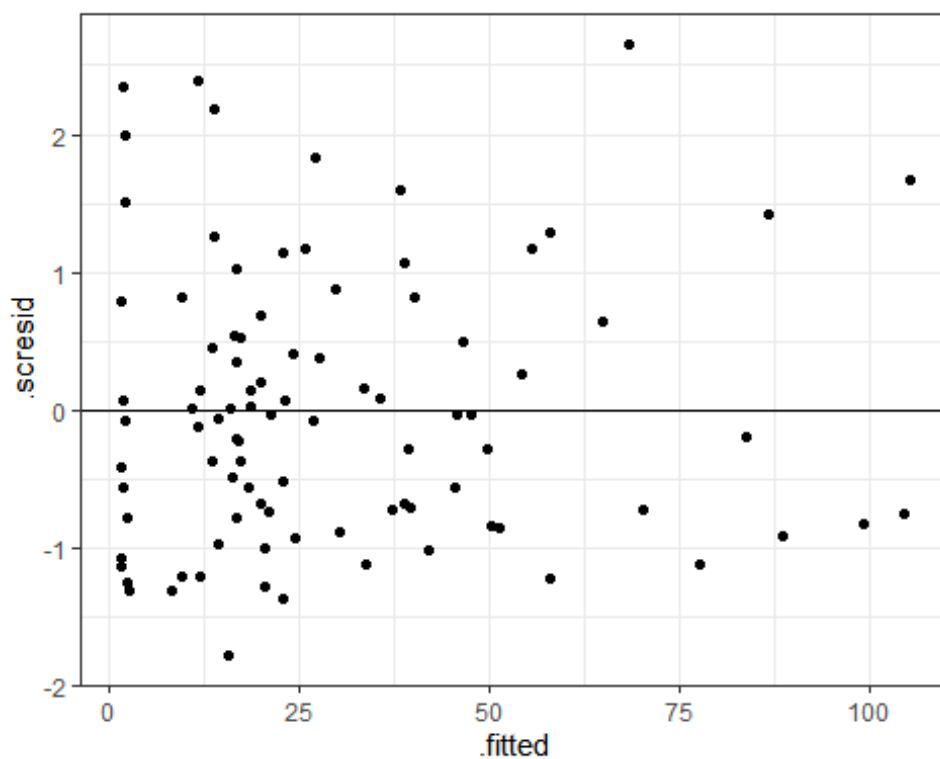
```
## Mod33    20 729.6840
```

```
## Mod33.1  18 726.8099
```

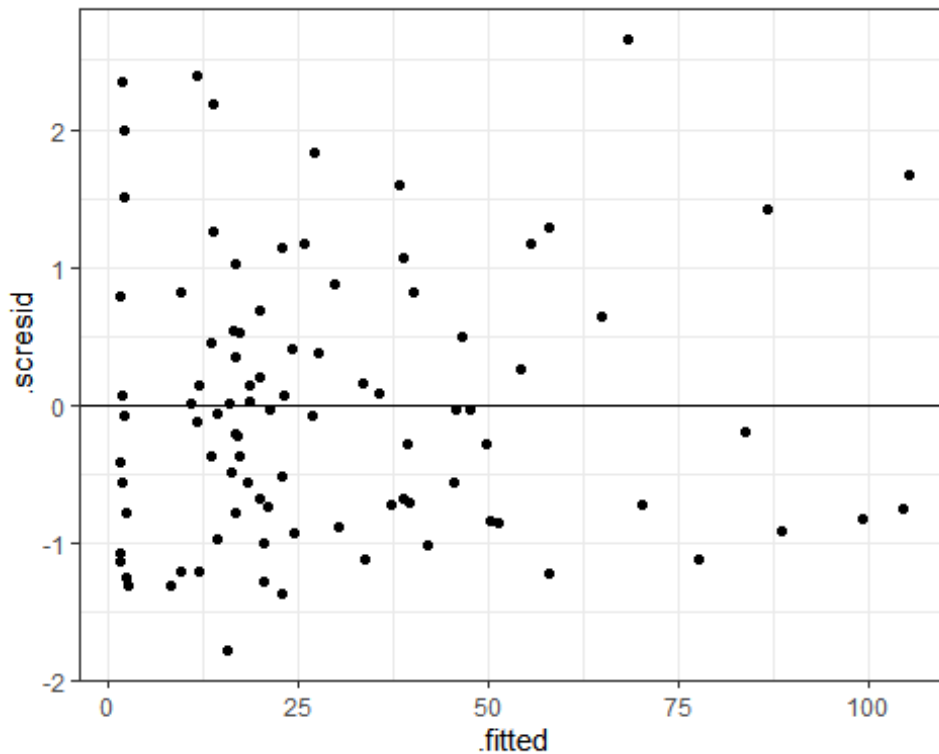
#Модель Mod33.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

#Диагностика модели (анализ остатков) - M33.1:без пропусков/с пропусками

```
model_diag(Mod33.1)
```



```
model_diag3(Mod33.1)
```



```
Mod34=glmer.nb(CountJ458~code+TSPMax+(1+TSPMax|year)+offset(lPop),PMdata,
               control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun = 2
00000)))

## boundary (singular) fit: see ?isSingular

summary(Mod34)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(4.6933) ( log )
## Formula: CountJ458 ~ code + TSPMax + (1 + TSPMax | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##      AIC      BIC   logLik deviance df.resid
##  730.7    781.3   -345.3    690.7      73
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.7943 -0.7933 -0.1697  0.5859  2.6094
##
## Random effects:
##  Groups Name            Variance Std.Dev. Corr
##  year  (Intercept)  0.0000    0.0000
##        TSPMax      0.1252    0.3539    NaN
## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##              Estimate Std. Error z value Pr(>|z|)
```

```

## (Intercept) -4.741011  0.367782 -12.891 < 2e-16 ***
## code2      -0.001911  0.361603 -0.005  0.99578
## code3       0.054119  0.313018  0.173  0.86274
## code4       1.031734  0.335790  3.073  0.00212 **
## code5       0.396829  0.298316  1.330  0.18344
## code6      -0.291326  0.367439 -0.793  0.42786
## code7       0.722431  0.338744  2.133  0.03295 *
## code8       0.056758  0.378508  0.150  0.88080
## code9       0.750577  0.264830  2.834  0.00459 **
## code10      -0.042775  0.260779 -0.164  0.86971
## code11       0.273414  0.268697  1.018  0.30889
## code12       0.601221  0.261216  2.302  0.02136 *
## code13       0.216853  0.267523  0.811  0.41760
## code14      -0.524399  0.276347 -1.898  0.05775 .
## code15      -0.470899  0.317320 -1.484  0.13781
## TSPMax      -0.725707  0.544636 -1.332  0.18271
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##     vcov(x)         if you need it

## optimizer (bobyqa) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular

overdisp_fun(Mod34)

##          chisq          ratio          rdf          p
## 91.46468884  1.25294094 73.00000000  0.07082978

Mod34.1=glmer.nb(CountJ458~code+TSPMax+(1|year)+offset(lPop),PMdata,
                 control=glmerControl(optimizer='bobyqa',optCtrl = list(maxfun =
200000)))
summary(Mod34.1)

## Generalized linear mixed model fit by maximum likelihood (Laplace
## Approximation) [glmerMod]
## Family: Negative Binomial(4.763) ( log )
## Formula: CountJ458 ~ code + TSPMax + (1 | year) + offset(lPop)
## Data: PMdata
## Control: glmerControl(optimizer = "bobyqa", optCtrl = list(maxfun = 2e+05))
##
##          AIC          BIC    logLik deviance df.resid
##      724.9      770.5   -344.4    688.9         75
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -1.8100 -0.8108 -0.0743  0.5192  2.5975
##
## Random effects:
## Groups Name          Variance Std.Dev.
## year   (Intercept) 0.04252  0.2062

```

```

## Number of obs: 93, groups: year, 7
##
## Fixed effects:
##           Estimate Std. Error z value Pr(>|z|)
## (Intercept) -4.752935   0.373074 -12.740 < 2e-16 ***
## code2        0.007676   0.359800   0.021  0.98298
## code3        0.067855   0.311370   0.218  0.82749
## code4        1.018136   0.334308   3.046  0.00232 **
## code5        0.413943   0.297179   1.393  0.16365
## code6       -0.251167   0.365483  -0.687  0.49194
## code7        0.726488   0.336215   2.161  0.03071 *
## code8        0.076943   0.377713   0.204  0.83858
## code9        0.774127   0.262193   2.953  0.00315 **
## code10       -0.028200   0.258486  -0.109  0.91313
## code11       0.282578   0.266892   1.059  0.28970
## code12       0.610412   0.259248   2.355  0.01855 *
## code13       0.248275   0.264895   0.937  0.34863
## code14      -0.508157   0.274890  -1.849  0.06452 .
## code15      -0.466763   0.316821  -1.473  0.14068
## TSPMax       -0.732694   0.519618  -1.410  0.15852
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 16 > 12.
## Use print(x, correlation=TRUE) or
##      vcov(x)      if you need it

overdisp_fun(Mod34.1)

##      chisq      ratio      rdf      p
## 88.9135227  1.1855136 75.0000000 0.1300405

getME(Mod34.1, 'glmer.nb.theta')

## [1] 4.762999

icc(Mod34.1)

## # Intraclass Correlation Coefficient
##
##      Adjusted ICC: 0.163
##      Conditional ICC: 0.089

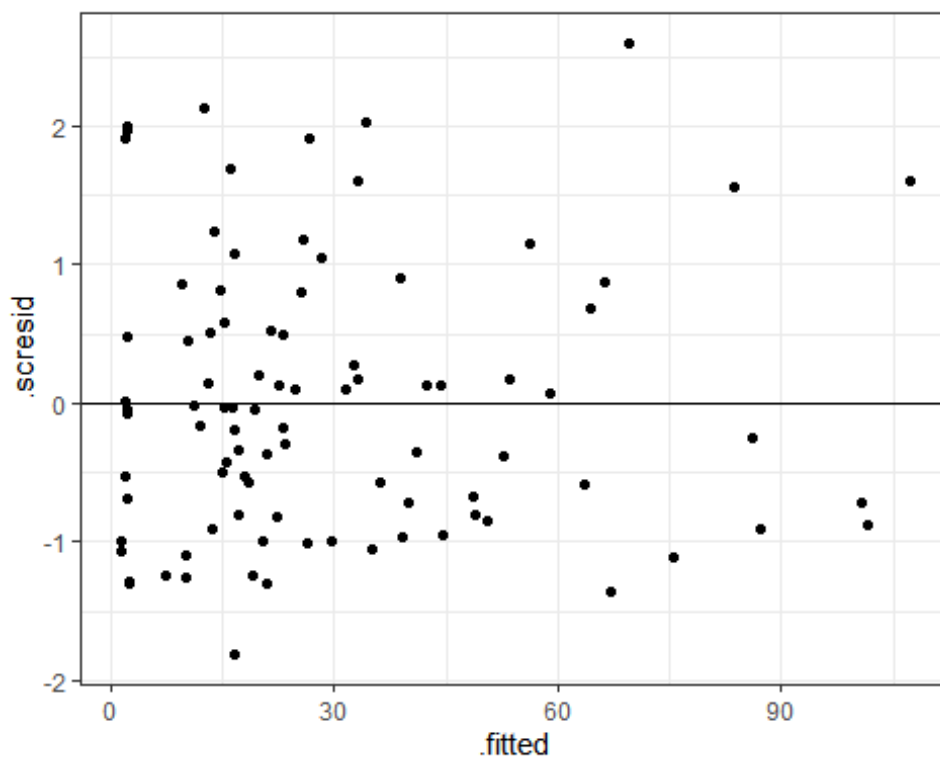
AIC(Mod34, Mod34.1)

##      df      AIC
## Mod34   20 730.6642
## Mod34.1 18 724.8766

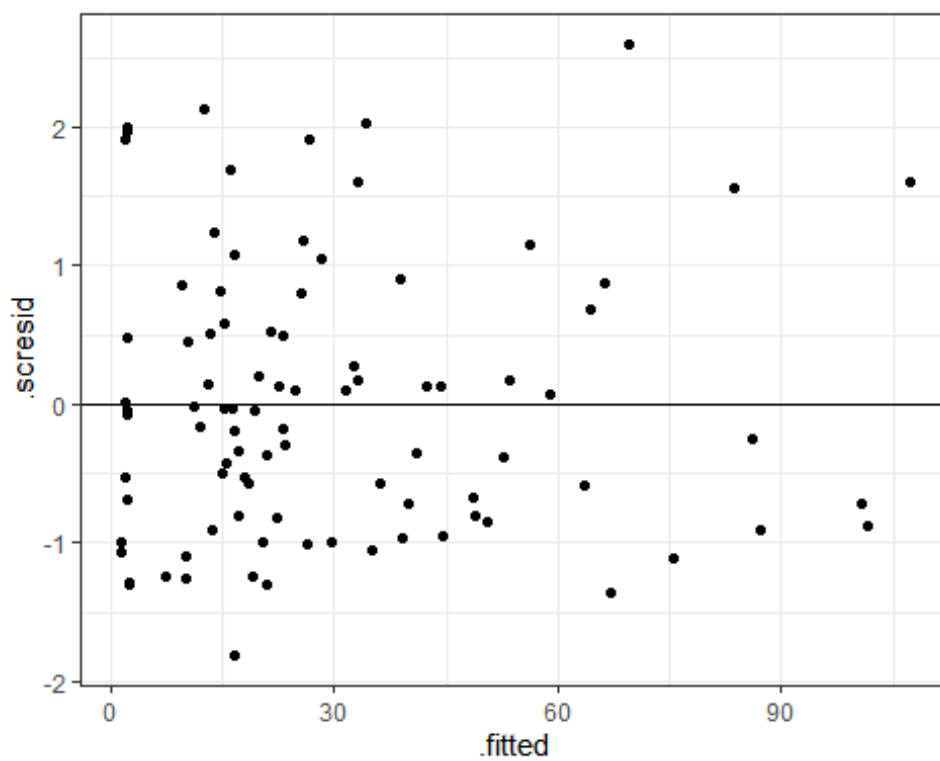
## Модель Mod34.1 (отрицательное биномиальное распределение) лучше подходит для данных!!!

```

#Диагностика модели (анализ остатков) - М34.1:без пропусков/с пропусками
`model_diag(Mod34.1)`



`model_diag3(Mod34.1)`




```
#эффект локации, и своя зависимость для переменных в каждой локации - нужно, чтобы были все локации
#M14.1=glmer.nb(data$CountJ451~code/(PM.2.5Max)+(1+PM.2.5Max|year)+offset(LPop),
data=data)
#summary(M14.1)
#Чтобы посмотреть, как реально строится линейный предиктор, можно посмотреть модельную матрицу
#model.matrix(~ fLocation/(PM025,data=p)
#model.matrix(~ code/(PM.2.5Max),data=data)

#M=glmer(J451Count~year+PM25+X+(1+ PM25|code/year)+offset(LPop),family="poisson",
data=p)
#модели от Савельева
#M=glmer(J451Count~code+PM25+(1|year)+offset(LPop),family="poisson",data=p)
#M=glmer(J451Count~code/(PM25)+(1|year)+offset(LPop),family="poisson",data=p)
```