Report11

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Data

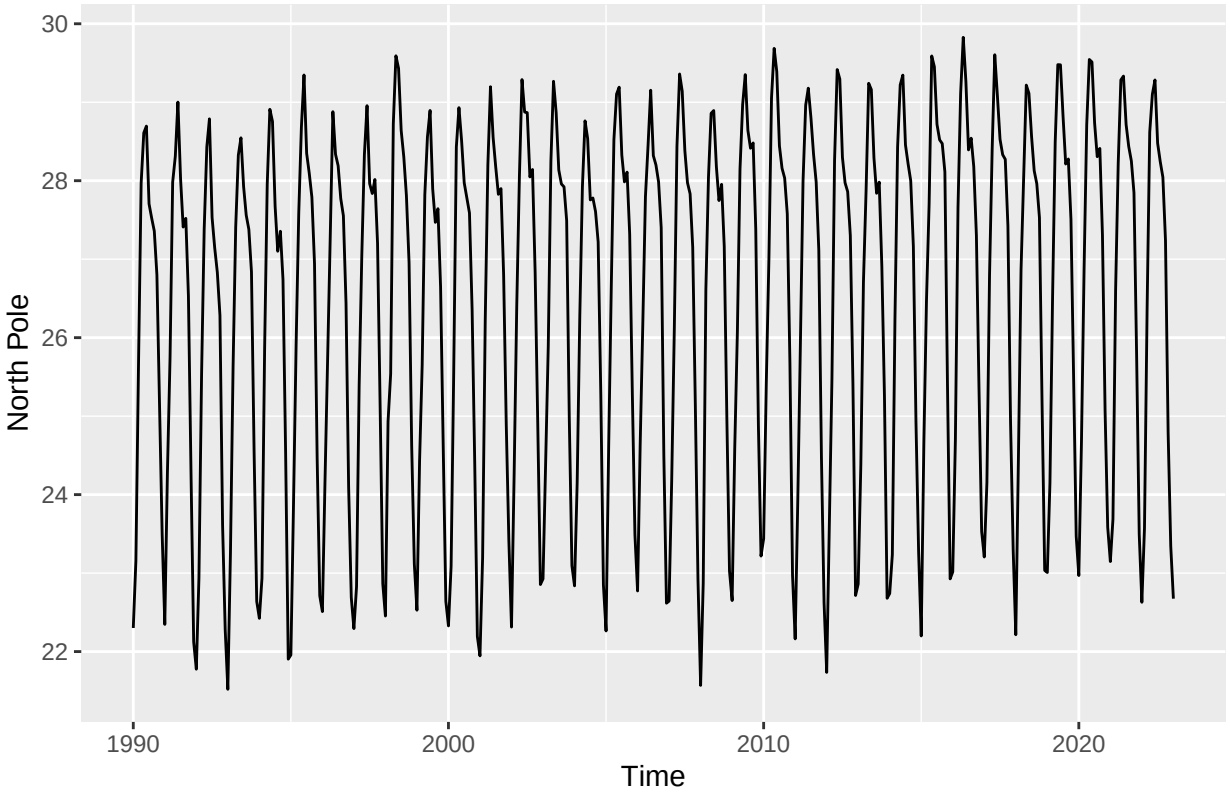
```
GLOBALTEMPERATURE = read.csv(file = "C:\\Users/ss/Desktop/Time_series_Analysis/MyGlobalTemperetures_Lan
global_temp = ts(GLOBALTEMPERATURE[,1], start = c(1850, 1), frequency = 12)
northernhemisphere_temp = ts(GLOBALTEMPERATURE[,2], start = c(1850, 1), frequency = 12)
southernhemisphere_temp = ts(GLOBALTEMPERATURE[,3], start = c(1850, 1), frequency = 12)

LattitudinalTemps = read.csv(file = "C:\\Users/ss/Desktop/Time_series_Analysis/LatittudCuttedTemperetur
northPole = ts(LattitudinalTemps[, "X3"], start = c(1850, 1), frequency = 12)
north = ts(LattitudinalTemps[, "X2"], start = c(1850, 1), frequency = 12)
trop_north = ts(LattitudinalTemps[, "X1"], start = c(1850, 1), frequency = 12)
trop_south = ts(LattitudinalTemps[, "X4"], start = c(1850, 1), frequency = 12)
south = ts(LattitudinalTemps[, "X5"], start = c(1850, 1), frequency = 12)
southPole = ts(LattitudinalTemps[, "X6"], start = c(1850, 1), frequency = 12)
```

Plots

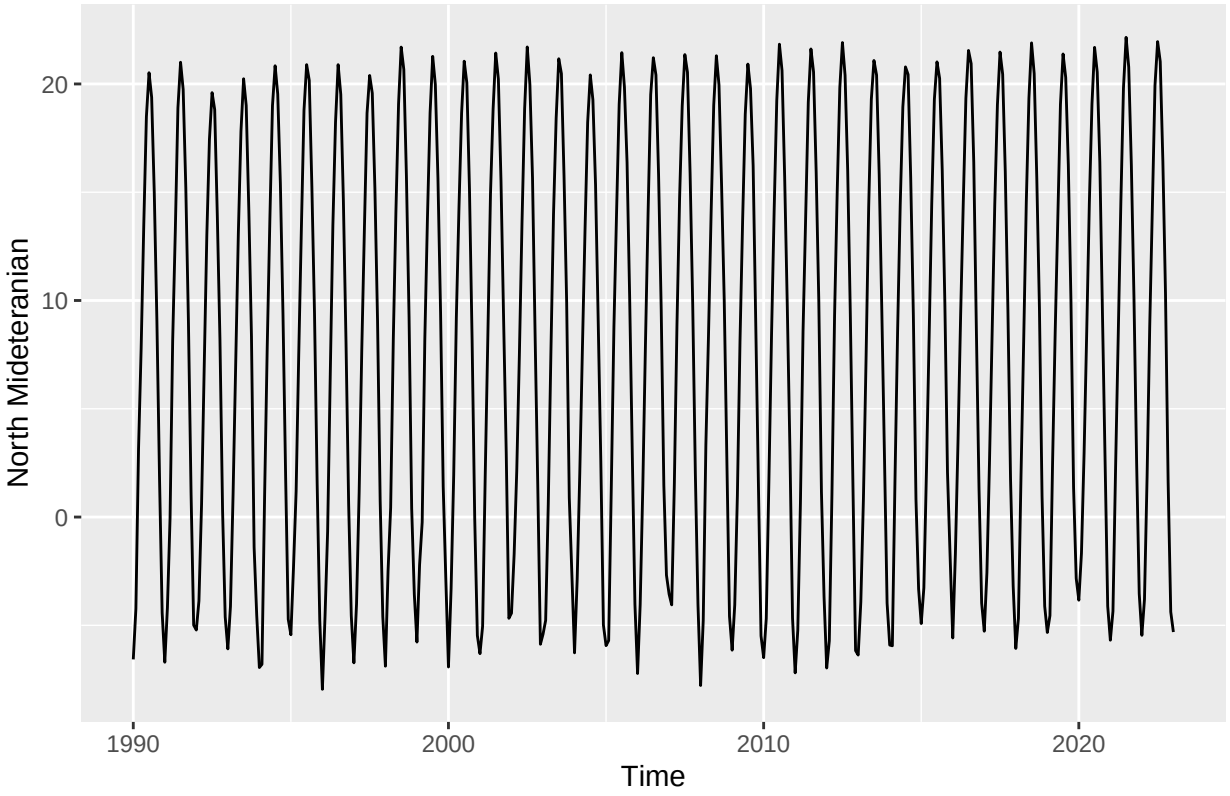
```
library(ggplot2)
library(gridExtra)
```

```
## Warning: package 'gridExtra' was built under R version 4.3.3
```

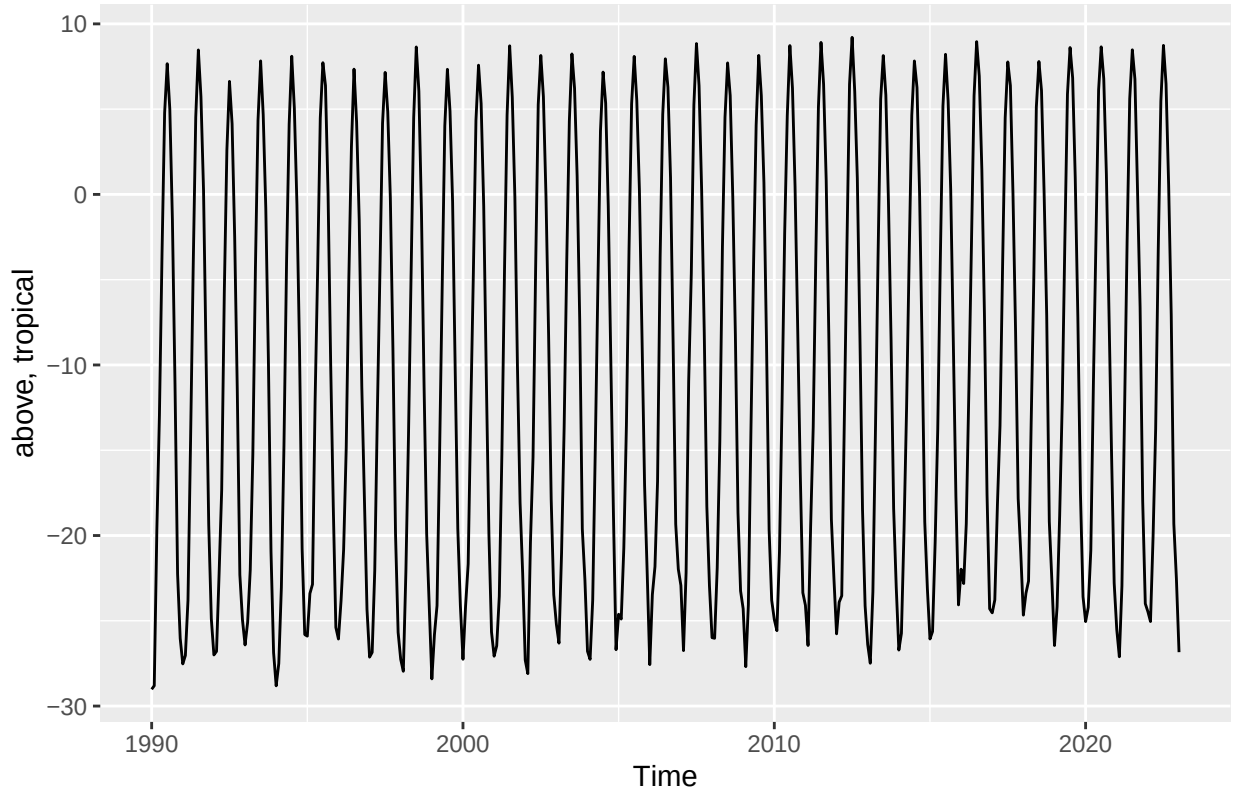
```
autoplot1 <- autoplot(window(northPole, start = c(1990, 1), freq = 12), ylab = "North Pole")

autoplot2 <- autoplot(window(north, start = c(1990, 1), freq = 12), ylab = "North Mideteranian")

autoplot3 <- autoplot(window(trop_north, start = c(1990, 1), freq = 12), ylab = "above, tropical")

autoplot4 <- autoplot(window(trop_south, start = c(1990, 1), freq = 12), ylab = "below tropical")

autoplot5 <- autoplot(window(south, start = c(1990, 1), freq = 12), ylab = "southern middle strip")

autoplot6 <- autoplot(window(southPole, start = c(1990, 1), freq = 12), ylab = "south pole")


par(mfrow = c(1, 6))
plot(autoplot1)
```



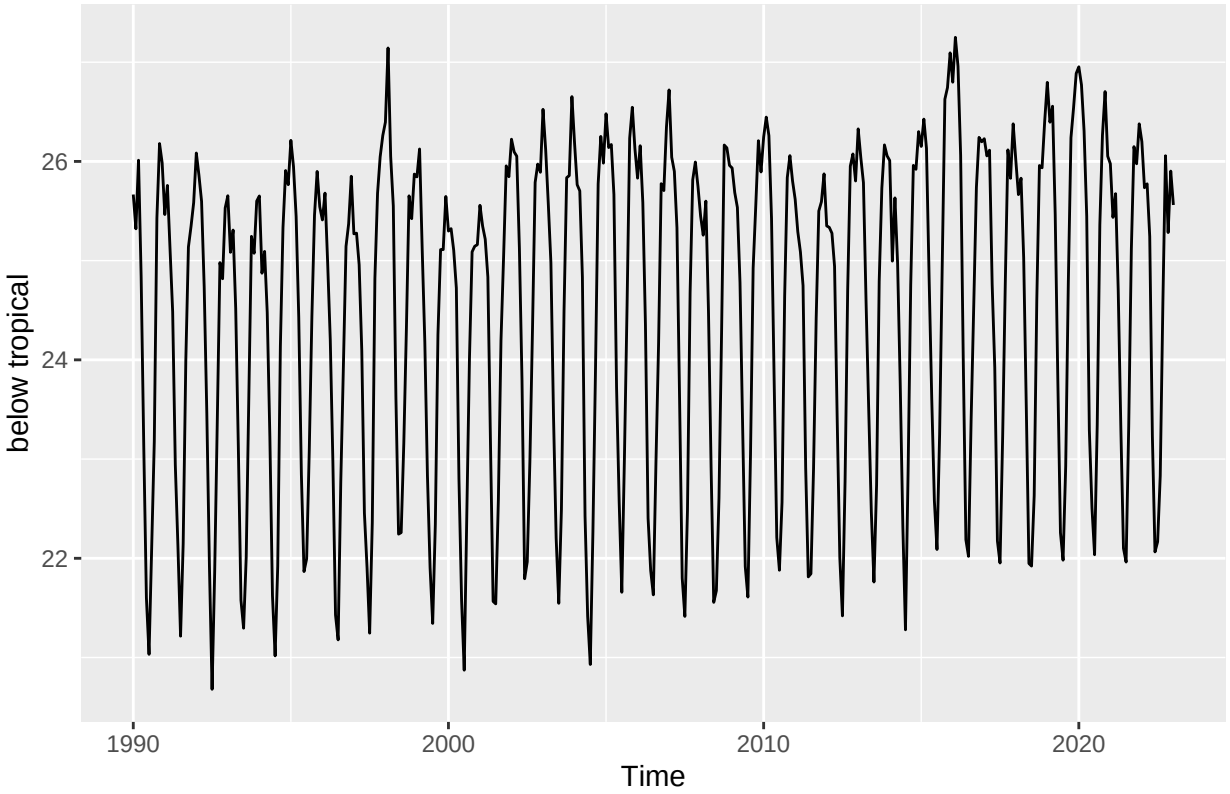

```
plot(autoplot2)
```



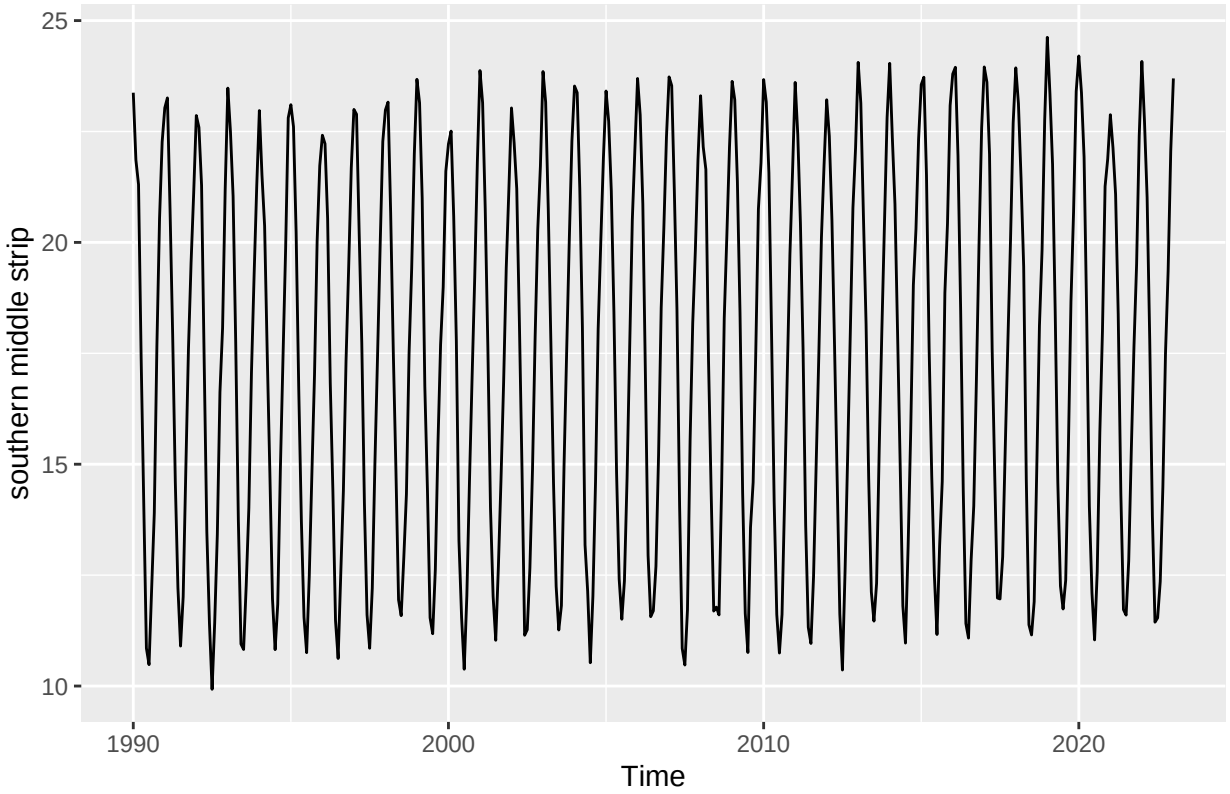

```
plot(autoplot3)
```



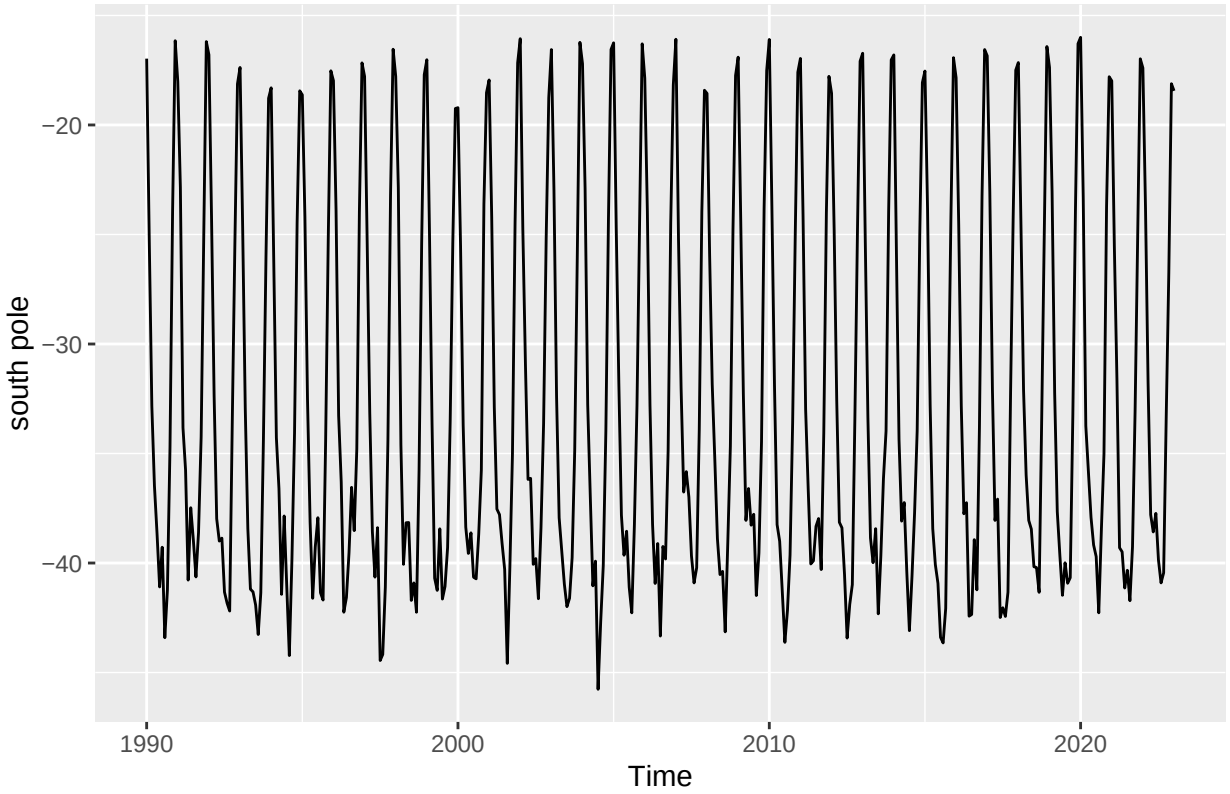

```
plot(autoplot4)
```



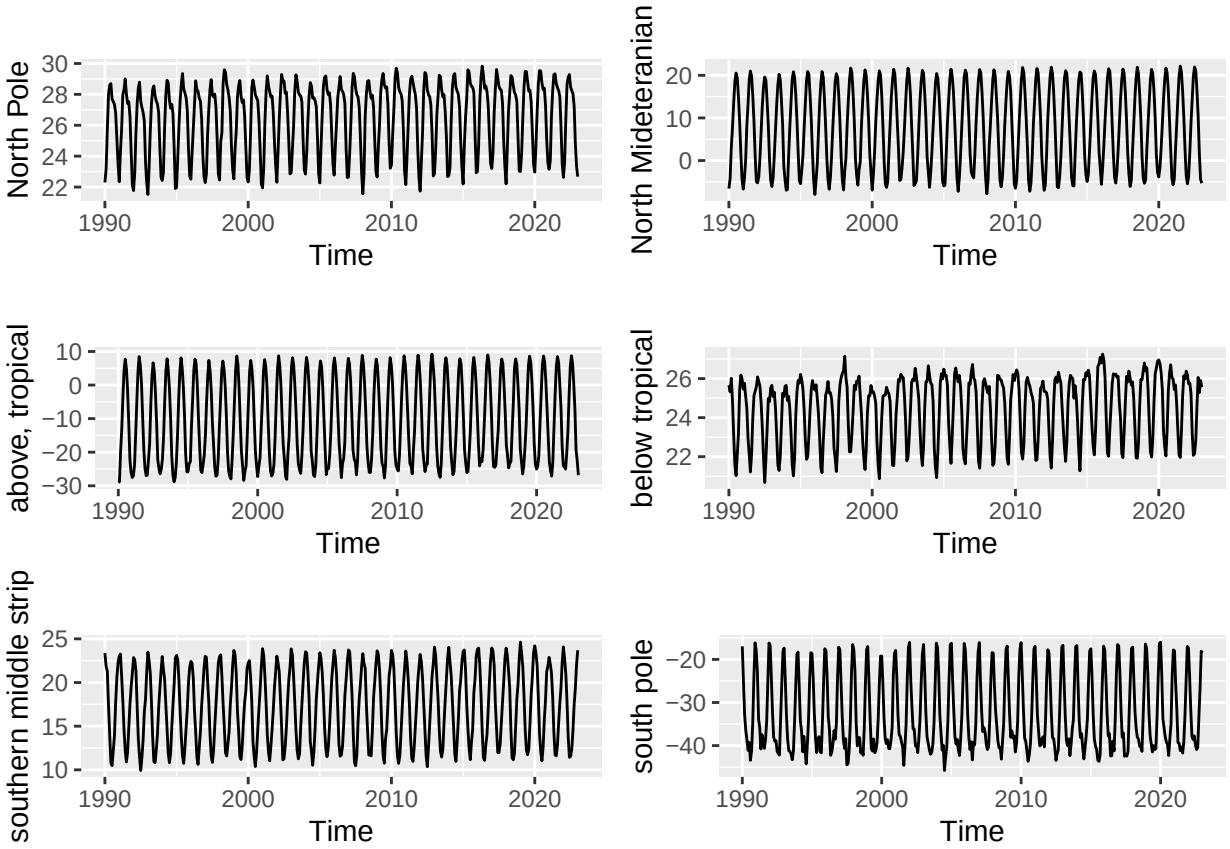

```
plot(autoplot5)
```




```
plot(autoplot6)
```




```
layout(matrix(c(1, 2, 3, 4, 5), nrow = 1))
grid.arrange(autoplot1, autoplot2, autoplot3, autoplot4, autoplot5, autoplot6)
```



Different Earth strips

- northPole: latitude from 60^o to 90^o.
- north: latitude from 30^o to 60^o.
- trop_north: latitude from 0^o to 30^o.
- trop_south: latitude from 0^o to -30^o.
- south: latitude from -30^o to -60^o.
- southPole: latitude from -60^o to -90^o.

```
Arima_fittng <- function(timeseries, startingPoint = start(timeseries), endingPoint = end(timeseries)){
  cutted_data = window(timeseries, start = startingPoint, end = endingPoint, freq = 12)
  t = seq_along(cutted_data)
  regressors = cbind(sin(pi/6*t), cos(pi/6*t), t)
  arima_fit = auto.arima(cutted_data, xreg = regressors, approximation = FALSE, seasonal = TRUE)
  return(arima_fit)
}

global_fitting_Arimareg = Arima_fittng(global_temp, startingPoint = c(1985, 1))

summary(global_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(2,0,3) errors
##
```

```
## Coefficients:
##           ar1     ar2     ma1      ma2      ma3  intercept
##       -0.0126  0.7006  0.3684  -0.4014  -0.0968    14.2716  -0.9677  -1.5120
## s.e.   0.1688  0.1248  0.1727   0.1130   0.0630     0.0407   0.0135   0.0135
##           t
##       0.0018
## s.e.  0.0002
##
## sigma^2 = 0.02576:  log likelihood = 191.96
## AIC=-363.93   AICc=-363.44   BIC=-322.68
##
## Training set error measures:
##                         ME      RMSE       MAE         MPE      MAPE      MASE
## Training set 0.0002486766 0.1589078 0.1251392 -0.01158384 0.8755781 0.6351203
##                     ACF1
## Training set 0.001032067
```

```
northPole_fitting_Arimareg = Arima_fittng(northPole, startingPoint = c(1980, 1))
north_fitting_Arimareg = Arima_fittng(north, startingPoint = c(1980, 1))
trop_north_fitting_Arimareg = Arima_fittng(trop_north, startingPoint = c(1980, 1))
trop_south_fitting_Arimareg = Arima_fittng(trop_south, startingPoint = c(1980, 1))
south_fitting_Arimareg = Arima_fittng(south, startingPoint = c(1980, 1))
southPole_fitting_Arimareg = Arima_fittng(southPole, startingPoint = c(1980, 1))
```

```
model_details <- data.frame(c(northPole_fitting_Arimareg$arma), c(north_fitting_Arimareg$arma), c(trop_n

model_details
```

```
##   c.northPole_fitting_Arimareg.arma. c.north_fitting_Arimareg.arma.
## 1                                  1                               1
## 2                                  0                               0
## 3                                  1                               2
## 4                                  0                               0
## 5                                 12                              12
## 6                                  0                               0
## 7                                  0                               0
##   c.trop_north_fitting_Arimareg.arma. c.trop_south_fitting_Arimareg.arma.
## 1                                   1                                   1
## 2                                   1                                   0
## 3                                   2                                   2
## 4                                   0                                   0
## 5                                  12                                  12
## 6                                   0                                   0
## 7                                   0                                   0
##   c.south_fitting_Arimareg.arma. c.southPole_fitting_Arimareg.arma.
## 1                              1                                  3
## 2                              0                                  0
## 3                              2                                  1
## 4                              0                                  0
## 5                             12                                 12
## 6                              0                                  0
## 7                              0                                  0
```

```r
summary(northPole_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(1,0,0)(1,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1  intercept                          t
##       0.4060  0.7724    25.9194  -0.8574  -2.9040  0.0018
## s.e.  0.0402  0.0274     0.2634   0.1807   0.1804  0.0008
##
## sigma^2 = 0.2362:  log likelihood = -363.1
## AIC=740.19   AICc=740.41   BIC=769.93
##
## Training set error measures:
##                        ME      RMSE       MAE         MPE     MAPE      MASE
## Training set -0.003698974 0.4831931 0.3730615 -0.05472521 1.460727 0.8738155
##                      ACF1
## Training set -0.01099241
```

```r
summary(north_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(1,0,0)(2,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1    sar2  intercept                            t
##       0.2928  0.1855  0.2528     7.0432  -7.2412  -11.4979  3e-03
## s.e.  0.0422  0.0425  0.0432     0.1582   0.1083    0.1082  5e-04
##
## sigma^2 = 0.5928:  log likelihood = -596.1
## AIC=1208.21   AICc=1208.49   BIC=1242.19
##
## Training set error measures:
##                        ME      RMSE       MAE      MPE     MAPE      MASE
## Training set -0.002197748 0.7646846 0.5786993 11.22289 30.63854 0.7690733
##                      ACF1
## Training set -0.01235676
```

```r
summary(trop_north_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(1,0,1)(2,0,0)[12] errors
##
## Coefficients:
##          ar1      ma1    sar1   sar2  intercept                              t
##       0.6672  -0.5062  0.2903  0.392   -11.6720  -10.4936  -14.0311  0.0042
## s.e.  0.1507   0.1743  0.0408  0.043     0.4336    0.2617    0.2614  0.0014
##
## sigma^2 = 1.599:  log likelihood = -854.52
## AIC=1727.05   AICc=1727.4   BIC=1765.28
##
```

```
## Training set error measures:
##                       ME     RMSE       MAE        MPE     MAPE      MASE
## Training set -0.01420732 1.254799 0.9225076 -0.5332841 22.52774 0.7617368
##                    ACF1
## Training set 0.00314081
```

```
summary(trop_south_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(1,0,0)(2,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1    sar2  intercept                       t
##       0.5771  0.4348  0.3794    23.9467  0.6998  2.0017  0.0015
## s.e.  0.0360  0.0403  0.0411     0.3081  0.1909  0.1906  0.0010
##
## sigma^2 = 0.1428:  log likelihood = -233.03
## AIC=482.05   AICc=482.33   BIC=516.03
##
## Training set error measures:
##                        ME      RMSE      MAE         MPE     MAPE      MASE
## Training set 0.0002757467 0.3752943 0.302247 -0.02259995 1.241574 0.7132813
##                     ACF1
## Training set -0.07714231
```

```
summary(south_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(1,0,0)(2,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1    sar2  intercept                       t
##       0.2979  0.2822  0.2502    16.9605  3.1644  5.2073  0.0014
## s.e.  0.0422  0.0427  0.0434     0.1252  0.0864  0.0863  0.0004
##
## sigma^2 = 0.2638:  log likelihood = -387.37
## AIC=790.74   AICc=791.02   BIC=824.72
##
## Training set error measures:
##                        ME      RMSE      MAE        MPE     MAPE      MASE
## Training set -0.004360253 0.5101558 0.404103 -0.1422314 2.506581 0.7687455
##                      ACF1
## Training set -0.003904747
```

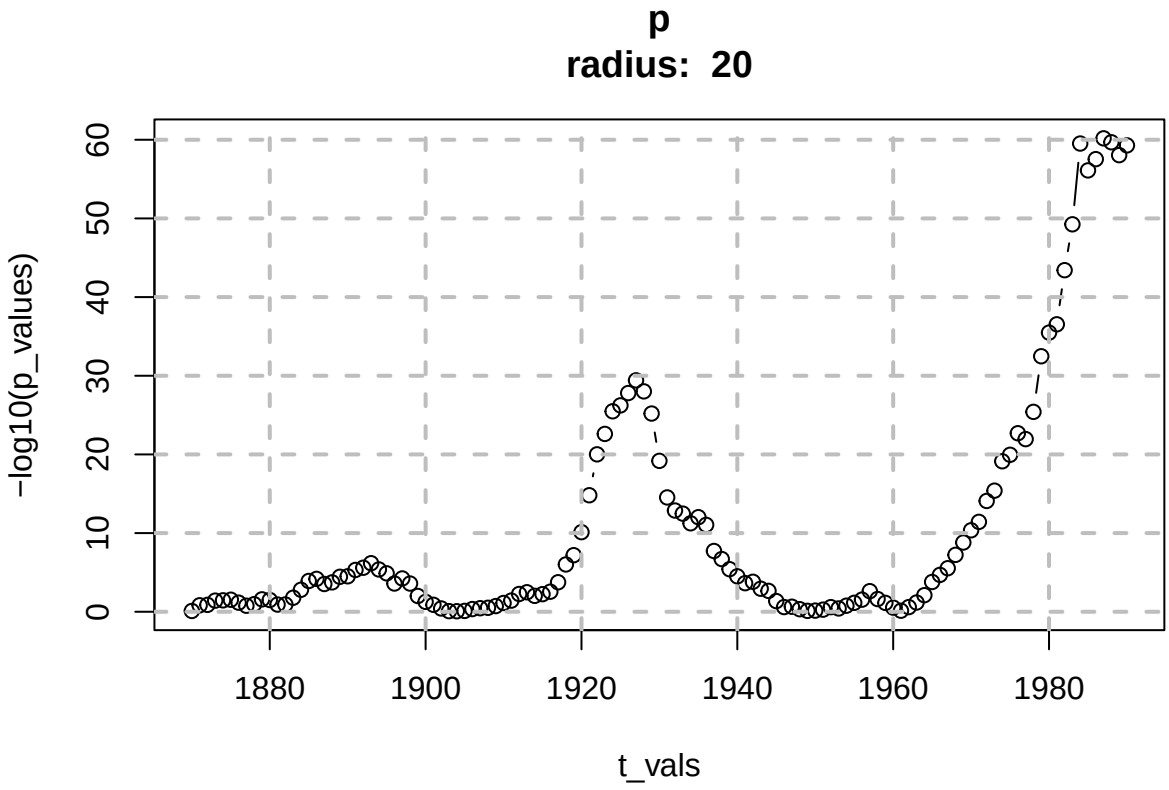
```
summary(southPole_fitting_Arimareg)
```

```
## Series: cutted_data
## Regression with ARIMA(3,0,0)(1,0,0)[12] errors
##
## Coefficients:
##          ar1      ar2      ar3    sar1  intercept                         t
##       0.3714  -0.3368  -0.4903  0.1524   -32.8767  3.9483  10.9408  0.0013
```

```
## s.e.  0.0385   0.0402   0.0394  0.0526     0.1170  0.1161   0.1163  0.0004
##
## sigma^2 = 2.743:  log likelihood = -991.84
## AIC=2001.68   AICc=2002.04   BIC=2039.92
##
## Training set error measures:
##                        ME     RMSE      MAE        MPE     MAPE      MASE
## Training set -0.004086165 1.643431 1.296531 -0.3846442 4.133181 0.8963679
##                      ACF1
## Training set -0.01221421
```

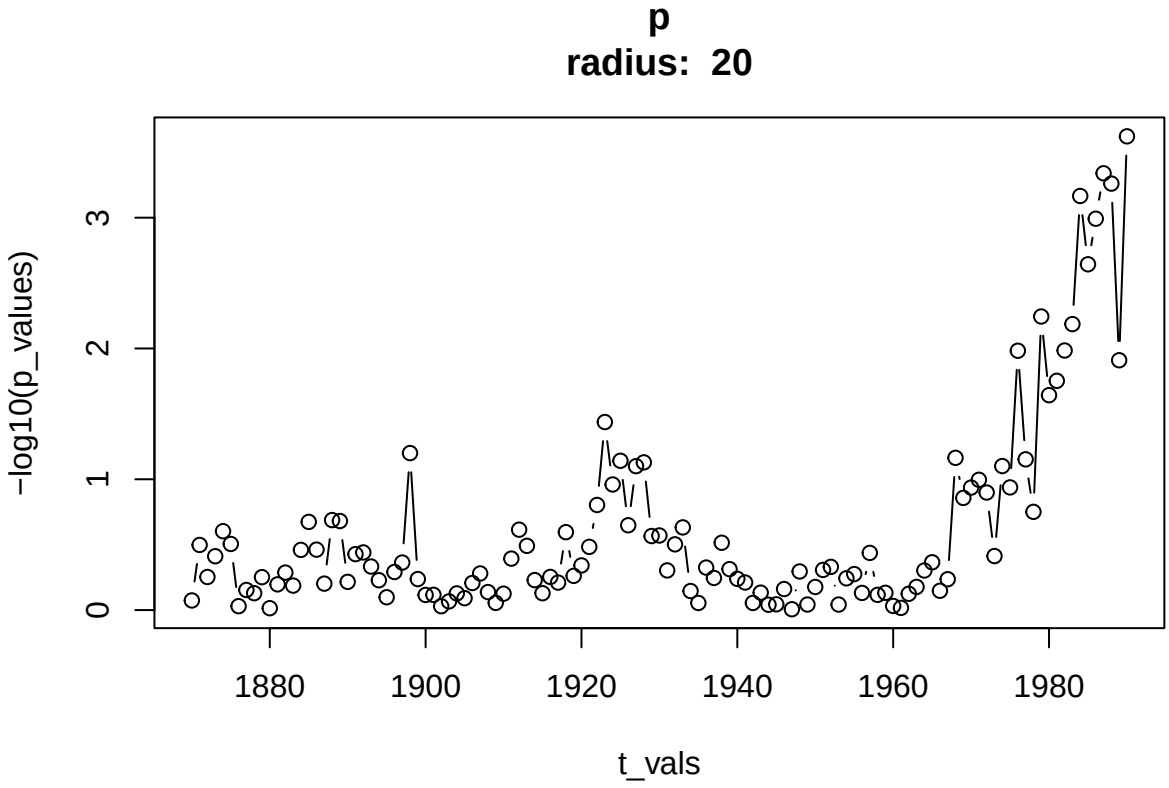
```r
# Helping functions

linear_coef <- function(DATA, x, Ord, sOrd, radius = 2){

  temporary_data = window(DATA, start = c(x-radius, 1), end = c(x+radius, 1))

  new_t <- seq_along(temporary_data)

  temporary_xreg = cbind(sin(new_t*pi/6), cos(new_t*pi/6), new_t)

  temporary_model = arima(temporary_data, order = Ord, seasonal = sOrd, xreg = temporary_xreg)

  std_error <- sqrt(diag(vcov(temporary_model)))

  return(c(as.numeric(temporary_model$coef["new_t"]), as.numeric(sqrt(diag(vcov(temporary_model)))["new
}


plot_Global_warming <- function(timeseries, arima_fit){

  #arima_fit = Arima_fittng(timeseries, startingPoint = c(1980, 1))


  ord = arima_fit$arma

  p = ord[1]; q = ord[2]; P = ord[3]; Q = ord[4]; period = ord[5]; d = ord[6]; D = ord[7];

  parameters =c()

  errors = c()

  rad = 20

  sp = 1850

  fp = 2023

  for (i in (sp + rad):(fp - rad)){
      u = linear_coef(timeseries,  i, c(p, d, q), c(P, D, Q) , rad)
      parameters <- cbind(parameters, u[1])
      errors <- cbind(errors, u[2])
  }
```

```
  t_vals = c((sp + rad):(fp - rad))

  MyPlot = (plot(t_vals, parameters, type='b', main=paste("c\nradius: ", toString(rad)), ylim = c(-0.01
    arrows(x0=t_vals, y0=parameters-2*errors, x1 = t_vals, y1=parameters+2*errors, code=3, angle = 90, l
    grid(nx = NULL, ny = NULL,
     lty = 2,      # Grid line type
     col = "gray", # Grid line color
     lwd = 2)      # Grid line width

  return(list(arima_fit, parameters, errors, MyPlot))
}


plot_p_vals <- function(timeseries, arima_fit, r){


  ord = arima_fit$arma

  p = ord[1]; q = ord[2]; P = ord[3]; Q = ord[4]; period = ord[5]; d = ord[6]; D = ord[7];

  parameters =c()

  errors = c()

  p_values = c()

  rad = r

  sp = 1850

  fp = 2010

  for (i in (sp + rad):(fp - rad)){
      u = linear_coef(timeseries,  i, c(p, d, q), c(P, D, Q) , rad)
      parameters <- cbind(parameters, u[1])
      errors <- cbind(errors, u[2])
      p = 2*pnorm(min(0, 2*u[1]), mean = u[1], sd = u[2], lower.tail = TRUE)
      p_values = cbind(p_values, p)
  }

  t_vals = c((sp + rad):(fp - rad))

  plot(t_vals, -log10(p_values), type='b', main=paste("p\nradius: ", toString(rad)))

}

plot_p_vals(global_temp, arima_fit = global_fitting_Arimareg, 20)+
    grid(nx = NULL, ny = NULL,
     lty = 2,      # Grid line type
     col = "gray", # Grid line color
     lwd = 2)      # Grid line width
```

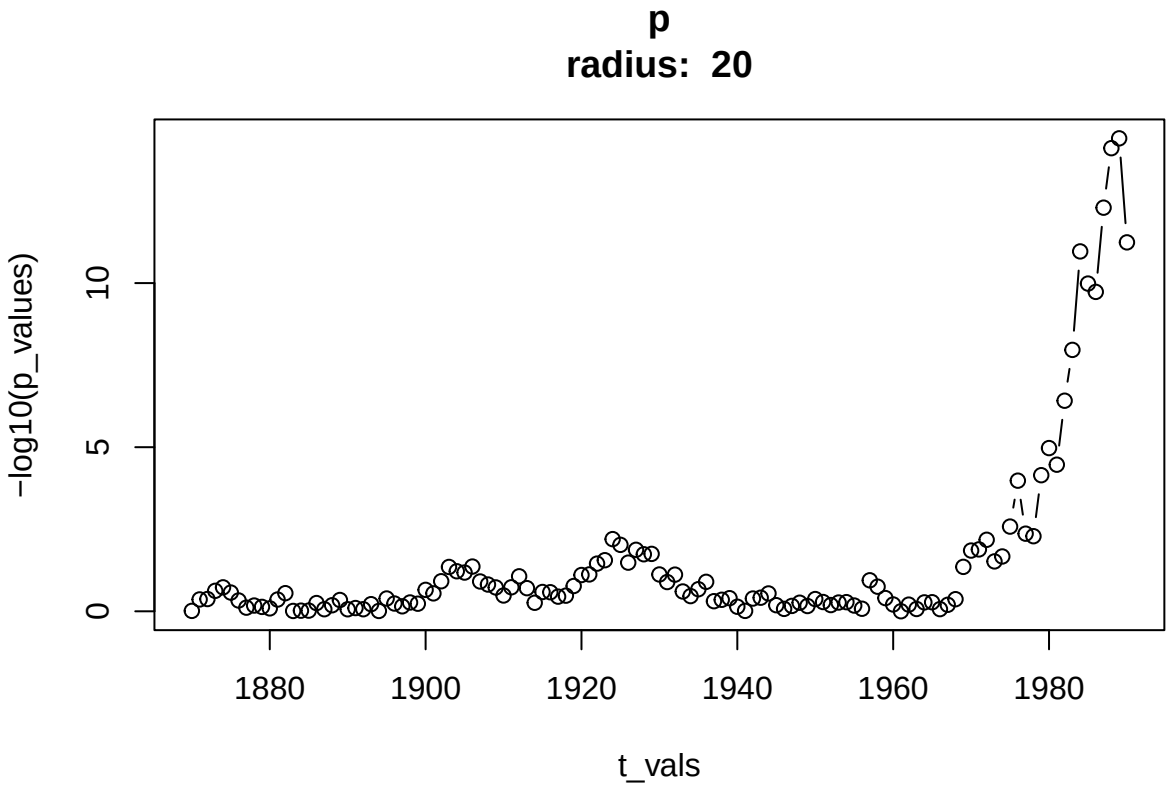



```
## integer(0)
```

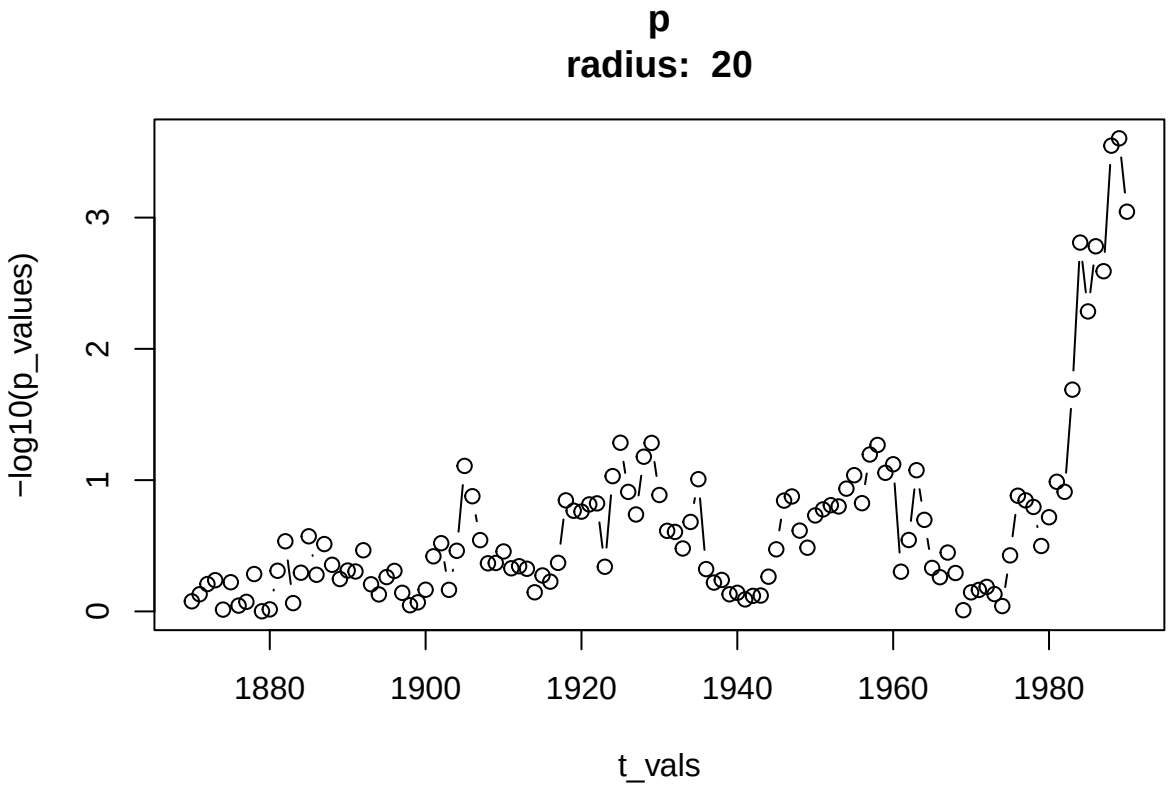
```
plot_p_vals(northPole, arima_fit = northPole_fitting_Arimareg, 20)
```



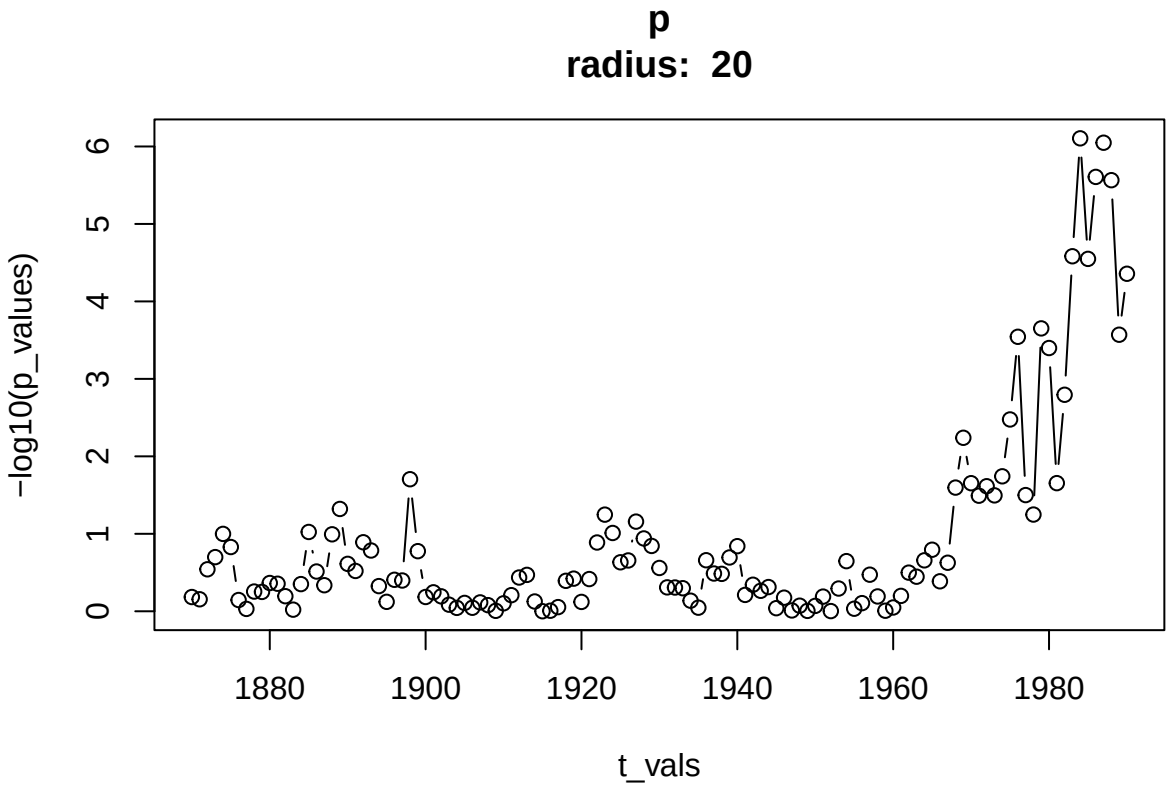

```
plot_p_vals(north, arima_fit = north_fitting_Arimareg, 20)
```



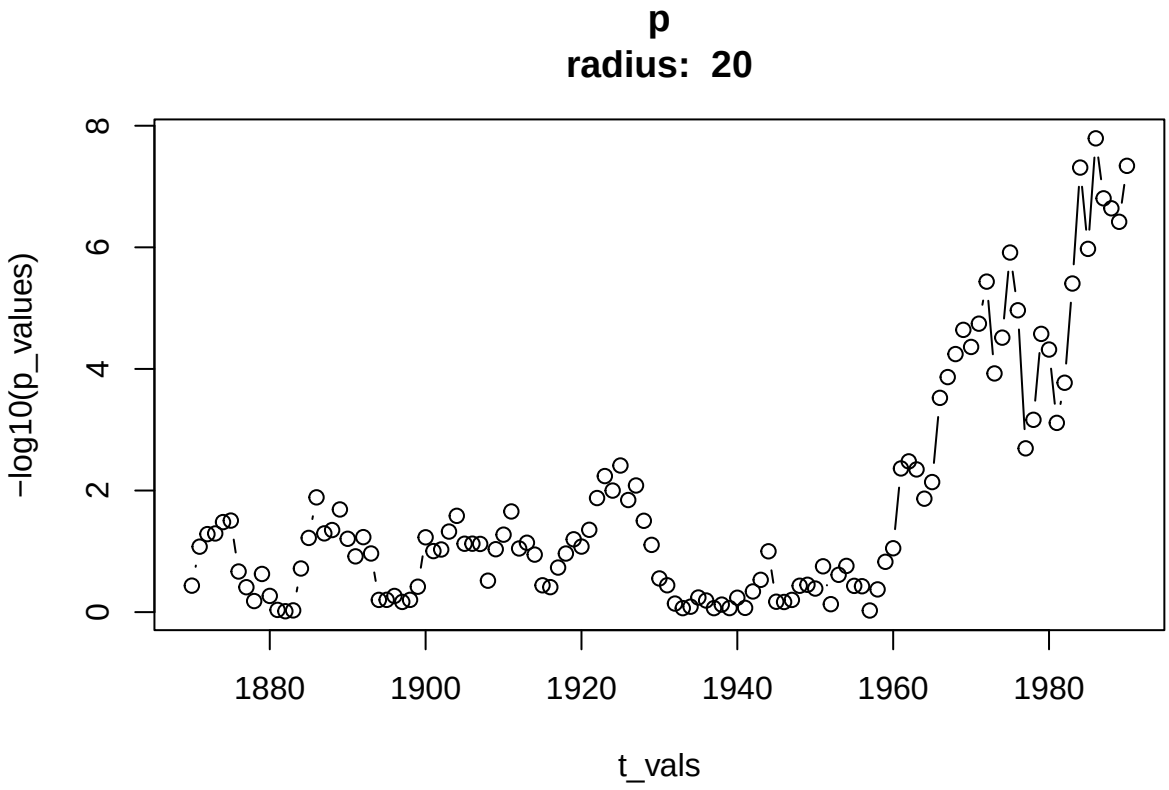

```
plot_p_vals(trop_north, arima_fit = trop_north_fitting_Arimareg, 20)
```




```
plot_p_vals(trop_south, arima_fit = trop_south_fitting_Arimareg, 20)
```



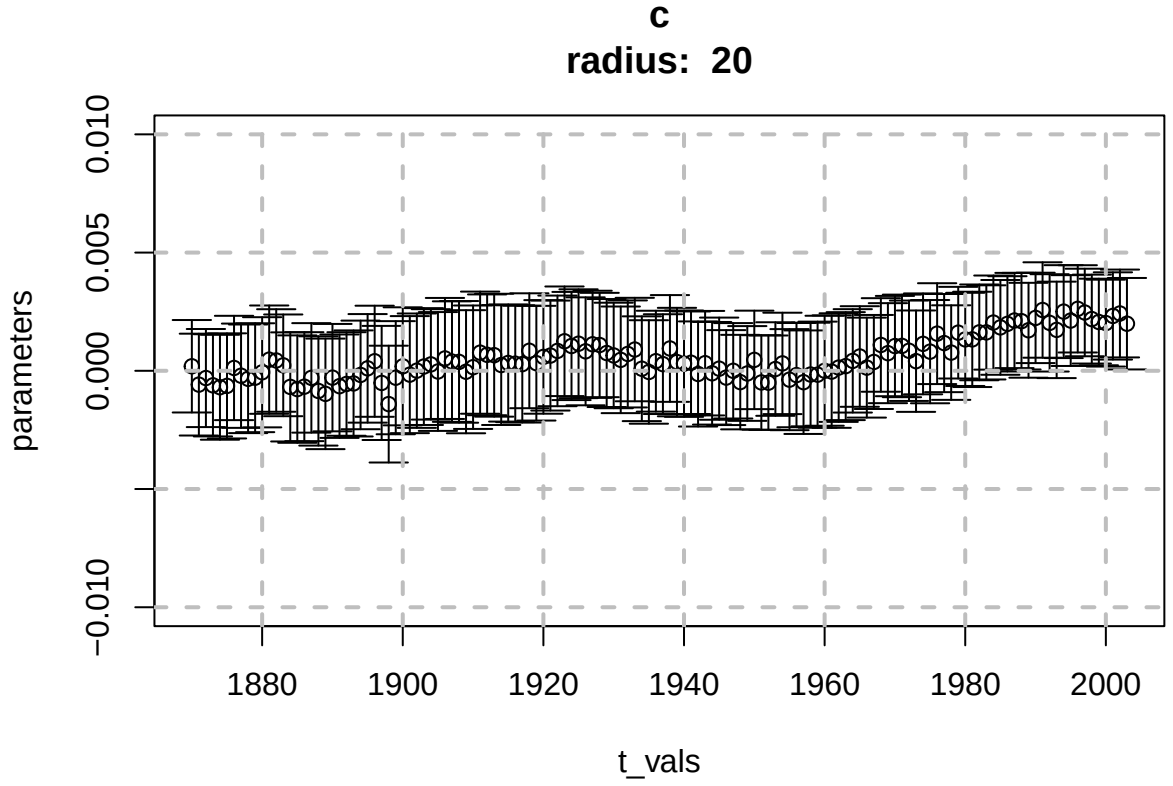

```
plot_p_vals(south, arima_fit = south_fitting_Arimareg, 20)
```




```
# plot_p_vals(southPole, arima_fit = southPole_fitting_Arimareg, 20)
```

Error. Again.

```
plot_Global_warming(northPole, arima_fit = northPole_fitting_Arimareg)
```

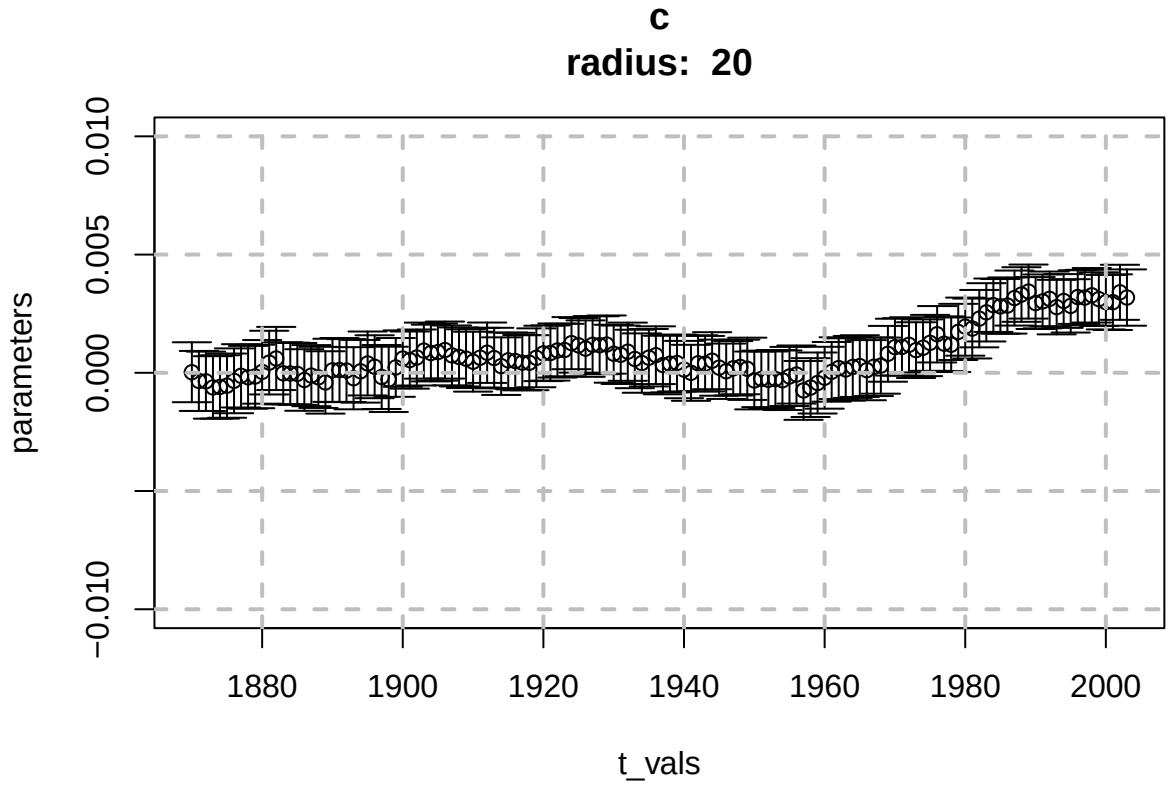



```
## [[1]]
## Series: cutted_data
## Regression with ARIMA(1,0,0)(1,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1  intercept                          t
##       0.4060  0.7724    25.9194  -0.8574  -2.9040  0.0018
## s.e.  0.0402  0.0274     0.2634   0.1807   0.1804  0.0008
##
## sigma^2 = 0.2362:  log likelihood = -363.1
## AIC=740.19   AICc=740.41   BIC=769.93
##
## [[2]]
##               [,1]         [,2]          [,3]          [,4]          [,5]
## [1,] 0.0001921362 -0.000583924 -0.0003068047 -0.0006149933 -0.0006952732
##               [,6]         [,7]          [,8]          [,9]         [,10]
## [1,] -0.0006384996 0.0001200245 -0.0002081711 -0.0003391221 -0.0002923326
##              [,11]        [,12]         [,13]         [,14]         [,15]
## [1,] -6.284159e-05 0.0004717733 0.0004358201 0.0002306876 -0.0006815069
##              [,16]         [,17]         [,18]         [,19]         [,20]
## [1,] -0.0007738111 -0.0006709846 -0.0002998343 -0.0008526846 -0.0009759179
##              [,21]         [,22]         [,23]         [,24]         [,25]
## [1,] -0.000289449 -0.0006507957 -0.0005573748 -0.0005340586 -0.0001743574
##              [,26]        [,27]         [,28]        [,29]        [,30]
## [1,] 0.0001032019 0.0004037288 -0.0005133511 -0.001408514 -0.000291983
##              [,31]         [,32]        [,33]         [,34]        [,35]
```

```
## [1,] 0.0001890152 -0.0001621974 5.277294e-06 0.0001794731 0.0002707958
##              [,36]        [,37]        [,38]        [,39]         [,40]
## [1,] -2.961155e-05 0.0005222184 0.0003894331 0.0003774348 -3.963399e-05
##             [,41]        [,42]        [,43]        [,44]        [,45]
## [1,] 0.0001515662 0.0007667748 0.0006753833 0.0006593143 0.0002442608
##             [,46]        [,47]        [,48]        [,49]        [,50]
## [1,] 0.0003299662 0.0003008189 0.0002824381 0.0008473821 0.0003214255
##             [,51]        [,52]        [,53]       [,54]       [,55]       [,56]
## [1,] 0.0005869161 0.0006439776 0.0008419046 0.001248594 0.001049365 0.001145702
##             [,57]       [,58]       [,59]        [,60]        [,61]
## [1,] 0.0008232839 0.001120799 0.001090249 0.0007515795 0.0006481726
##             [,62]        [,63]        [,64]        [,65]         [,66]
## [1,] 0.0004638532 0.0007131848 0.0008986831 8.730885e-05 -4.965523e-05
##             [,67]        [,68]       [,69]        [,70]        [,71]
## [1,] 0.0004065283 0.0002816127 0.000944547 0.0003693012 0.0003010942
##             [,72]        [,73]        [,74]         [,75]        [,76]
## [1,] 0.0003411543 -0.000133891 0.0003219778 -0.0001048898 8.957279e-05
##              [,77]         [,78]         [,79]         [,80]        [,81]
## [1,] -0.0002874574 -1.748144e-07 -0.0004781168 -0.0001134039 0.0004607451
##              [,82]        [,83]        [,84]        [,85]         [,86]
## [1,] -0.0004928098 -0.00050291 7.400321e-05 0.0003125143 -0.0003746879
##              [,87]         [,88]         [,89]         [,90]        [,91]
## [1,] -0.0001823812 -0.0004813375 -0.0001573592 -0.0001631291 2.687768e-06
##              [,92]        [,93]       [,94]        [,95]        [,96]
## [1,] -3.353076e-05 0.0001354281 0.000197332 0.0004200276 0.0006043258
##             [,97]        [,98]       [,99]       [,100]      [,101]     [,102]
## [1,] 0.0001341481 0.0003732287 0.001092488 0.0007454649 0.001045522 0.00105318
##            [,103]       [,104]      [,105]       [,106]      [,107]      [,108]
## [1,] 0.0008479087 0.0004067078 0.001139504 0.0008097929 0.001571238 0.001172079
##            [,109]     [,110]      [,111]      [,112]      [,113]      [,114]
## [1,] 0.0007700793 0.00161227 0.001328909 0.001328984 0.001625318 0.001624443
##            [,115]      [,116]      [,117]      [,118]      [,119]      [,120]
## [1,] 0.002039621 0.001836293 0.001984723 0.002127619 0.002098798 0.001714123
##            [,121]      [,122]      [,123]      [,124]      [,125]      [,126]
## [1,] 0.002236687 0.002571423 0.002026727 0.001730958 0.002502617 0.002124285
##            [,127]      [,128]      [,129]      [,130]      [,131]      [,132]
## [1,] 0.002620005 0.002465862 0.002186595 0.002064108 0.002016461 0.002319547
##            [,133]      [,134]
## [1,] 0.002423954 0.001991495
##
## [[3]]
##              [,1]        [,2]        [,3]        [,4]        [,5]        [,6]
## [1,] 0.0009776179 0.001076914 0.001037172 0.001080356 0.001109605 0.001111553
##             [,7]        [,8]        [,9]       [,10]       [,11]       [,12]
## [1,] 0.001102993 0.001102769 0.001148512 0.001151296 0.001164781 0.001145209
##            [,13]       [,14]       [,15]       [,16]       [,17]       [,18]
## [1,] 0.001084171 0.001075413 0.001153349 0.001135641 0.001151985 0.001157717
##            [,19]       [,20]       [,21]       [,22]       [,23]       [,24]
## [1,] 0.001155325 0.001169018 0.001135627 0.001093514 0.001094861 0.001121631
##            [,25]       [,26]       [,27]       [,28]       [,29]       [,30]
## [1,] 0.001148232 0.001147883 0.001174826 0.001206421 0.001234925 0.001196052
##           [,31]       [,32]       [,33]       [,34]       [,35]       [,36]
## [1,] 0.00124798 0.001237465 0.001209324 0.001235529 0.001167374 0.001256452
##            [,37]       [,38]       [,39]       [,40]       [,41]       [,42]
```

```
## [1,] 0.001279393 0.001274003 0.001286741 0.001301589 0.001305301 0.001291196
##            [,43]       [,44]       [,45]       [,46]      [,47]       [,48]
## [1,] 0.001277411 0.001299708 0.001268122 0.001238941 0.00123567 0.001235026
##            [,49]       [,50]       [,51]       [,52]       [,53]       [,54]
## [1,] 0.001214997 0.001212911 0.001200681 0.001162838 0.001170006 0.001159049
##            [,55]       [,56]       [,57]       [,58]       [,59]       [,60]
## [1,] 0.001143609 0.001150678 0.001141579 0.001132714 0.001103113 0.001141822
##            [,61]       [,62]       [,63]      [,64]       [,65]      [,66]
## [1,] 0.001115798 0.001127694 0.001131627 0.00109385 0.001107916 0.00109381
##            [,67]       [,68]       [,69]       [,70]       [,71]       [,72]
## [1,] 0.001066876 0.001055014 0.001128432 0.001146467 0.001124332 0.001084215
##            [,73]       [,74]       [,75]       [,76]       [,77]       [,78]
## [1,] 0.001111421 0.001105021 0.001084744 0.001080217 0.001003658 0.001008895
##             [,79]      [,80]       [,81]       [,82]       [,83]       [,84]
## [1,] 0.0009993954 0.0010019 0.001041121 0.0009991035 0.0009979286 0.0009891462
##            [,85]       [,86]       [,87]       [,88]       [,89]       [,90]
## [1,] 0.001071866 0.001068701 0.001102413 0.001094689 0.001095159 0.001121145
##            [,91]       [,92]       [,93]       [,94]       [,95]      [,96]
## [1,] 0.001162766 0.001189319 0.001148289 0.001141335 0.001093353 0.00106349
##            [,97]       [,98]       [,99]      [,100]      [,101]      [,102]
## [1,] 0.001056707 0.000993973 0.0009890506 0.001057537 0.001060419 0.001084613
##           [,103]      [,104]      [,105]      [,106]      [,107]      [,108]
## [1,] 0.001061147 0.00107194 0.001066979 0.00109169 0.001066319 0.001037779
##            [,109]      [,110]      [,111]      [,112]      [,113]
## [1,] 0.0009998349 0.0009688404 0.0009851235 0.001007744 0.001012709
##            [,114]      [,115]      [,116]      [,117]      [,118]      [,119]
## [1,] 0.0009954679 0.0009948522 0.001002194 0.001007675 0.001006782 0.001021145
##           [,120]      [,121]      [,122]      [,123]      [,124]      [,125]
## [1,] 0.001003181 0.0009555478 0.001009008 0.001029019 0.001019828 0.0009824331
##            [,126]      [,127]      [,128]      [,129]      [,130]
## [1,] 0.0009598286 0.0009224743 0.0009256974 0.0009399414 0.0009155392
##            [,131]      [,132]      [,133]      [,134]
## [1,] 0.0009187963 0.0009224883 0.0009286954 0.0009670838
##
## [[4]]
## integer(0)
```

```
plot_Global_warming(north, arima_fit = north_fitting_Arimareg)
```



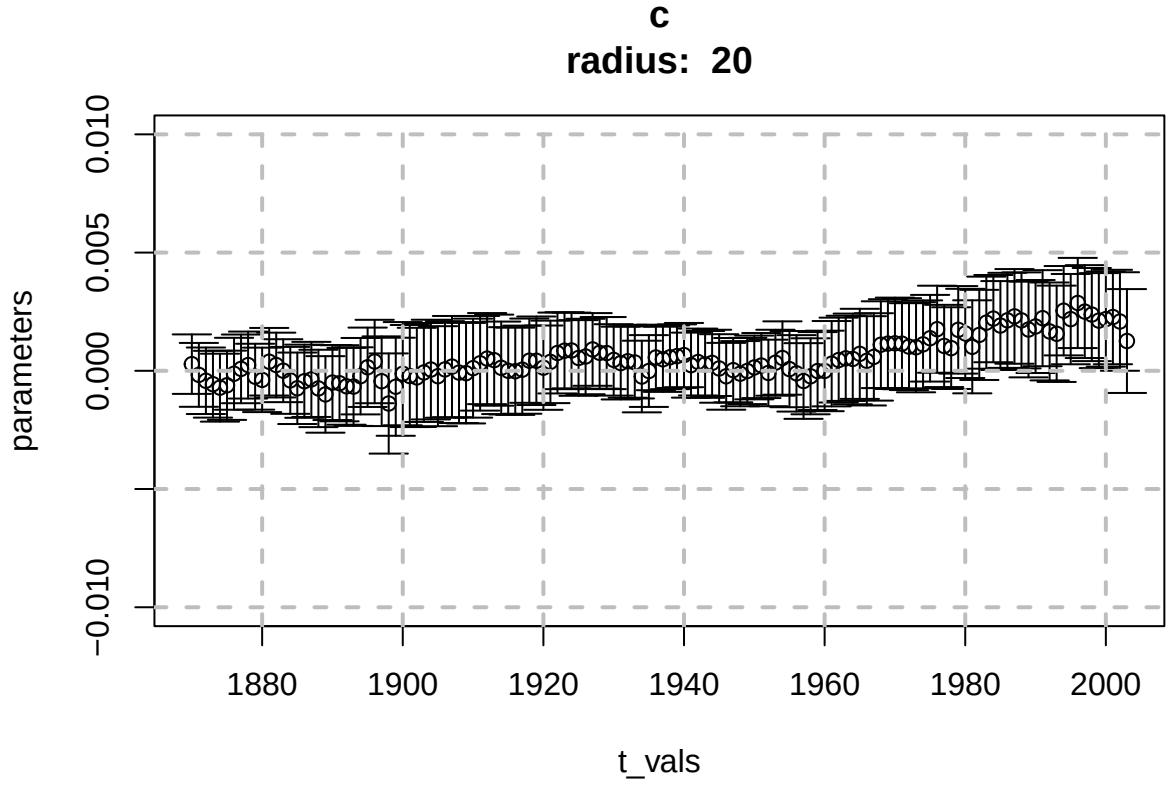

```
## [[1]]
## Series: cutted_data
## Regression with ARIMA(1,0,0)(2,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1    sar2  intercept                          t
##       0.2928  0.1855  0.2528     7.0432  -7.2412  -11.4979  3e-03
## s.e.  0.0422  0.0425  0.0432     0.1582   0.1083    0.1082  5e-04
##
## sigma^2 = 0.5928:  log likelihood = -596.1
## AIC=1208.21   AICc=1208.49   BIC=1242.19
##
## [[2]]
##              [,1]          [,2]          [,3]          [,4]          [,5]
## [1,] 2.374768e-05 -0.0003436018 -0.0003604955 -0.0006195092 -0.0005974718
##               [,6]          [,7]          [,8]         [,9]        [,10]
## [1,] -0.0005439954 -0.0003383842 -0.0001277876 -0.000190104 -0.000155224
##             [,11]       [,12]        [,13]         [,14]         [,15]
## [1,] 3.911222e-05 0.000430465 0.0006056451 -2.132836e-05 -2.949709e-05
##              [,16]         [,17]         [,18]         [,19]         [,20]
## [1,] -4.727707e-05 -0.0003045267 -0.0001196454 -0.0001936567 -0.0004076505
##             [,21]        [,22]        [,23]         [,24]        [,25]
## [1,] 0.0001049928 0.0001158295 9.428247e-05 -0.0002303601 6.417697e-05
##             [,26]        [,27]        [,28]         [,29]        [,30]
## [1,] 0.0003938203 0.0002561735 -0.000177034 -0.0002769347 0.0002271779
##             [,31]        [,32]        [,33]        [,34]        [,35]
```

```
## [1,] 0.0006025743 0.0005380864 0.0006470098 0.0009374032 0.0008355324
##             [,36]        [,37]        [,38]        [,39]        [,40]
## [1,] 0.0008752936 0.0009614754 0.0007352608 0.0006711288 0.0005973032
##             [,41]        [,42]        [,43]        [,44]        [,45]
## [1,] 0.0004705833 0.0006399274 0.0008490316 0.0006243927 0.0002816352
##             [,46]        [,47]        [,48]        [,49]        [,50]
## [1,] 0.0005266827 0.0004957507 0.0004280009 0.0004262715 0.0006337168
##            [,51]        [,52]        [,53]        [,54]       [,55]      [,56]
## [1,] 0.000820502 0.0008367419 0.0009424154 0.0009628946 0.001254419 0.00116077
##            [,57]      [,58]       [,59]       [,60]        [,61]        [,62]
## [1,] 0.001023587 0.00118567 0.001166289 0.001194483 0.0008069301 0.0007621093
##             [,63]        [,64]        [,65]        [,66]        [,67]
## [1,] 0.0008921224 0.0005850544 0.0004113527 0.0006390737 0.0007444352
##             [,68]        [,69]        [,70]        [,71]         [,72]
## [1,] 0.0003278779 0.0003841604 0.0004152404 0.0001371602 -1.581467e-06
##             [,73]        [,74]       [,75]        [,76]       [,77]      [,78]
## [1,] 0.0004020512 0.0003850098 0.000510856 0.0002181282 6.54636e-05 0.00018967
##             [,79]        [,80]         [,81]         [,82]         [,83]
## [1,] 0.0002465476 0.0001690296 -0.0003237896 -0.0002578104 -0.0002973419
##              [,84]         [,85]         [,86]         [,87]         [,88]
## [1,] -0.0002625746 -0.0003156403 -0.0001557899 -7.335145e-05 -0.0007452885
##              [,89]         [,90]         [,91]        [,92]        [,93]
## [1,] -0.0006257515 -0.0004318677 -0.0002086311 4.149785e-05 0.0001973516
##             [,94]        [,95]        [,96]       [,97]        [,98]
## [1,] 0.0001414283 0.0002478656 0.0002836507 0.000110149 0.0002549898
##             [,99]       [,100]      [,101]      [,102]      [,103]       [,104]
## [1,] 0.0003031099 0.0008029986 0.001084723 0.001095264 0.001181817 0.0009581786
##           [,105]     [,106]      [,107]      [,108]      [,109]      [,110]
## [1,] 0.001058692 0.00126702 0.001629371 0.001231792 0.001186035 0.001729256
##           [,111]      [,112]     [,113]     [,114]      [,115]      [,116]
## [1,] 0.001952339 0.001872642 0.00229044 0.00255726 0.002858634 0.002809612
##           [,117]      [,118]      [,119]      [,120]      [,121]      [,122]
## [1,] 0.002844744 0.003160687 0.003310636 0.003435243 0.002949571 0.003018839
##           [,123]    [,124]      [,125]      [,126]      [,127]      [,128]
## [1,] 0.003127386 0.0027783 0.003037485 0.002830024 0.003202409 0.003180327
##           [,129]      [,130]      [,131]      [,132]      [,133]      [,134]
## [1,] 0.003277975 0.003115396 0.002987665 0.002987566 0.003404034 0.003182367
##
## [[3]]
##              [,1]       [,2]        [,3]        [,4]         [,5]        [,6]
## [1,] 0.0006340614 0.00063438 0.000627925 0.000660318 0.0006699224 0.000678941
##              [,7]         [,8]         [,9]        [,10]        [,11]
## [1,] 0.0006854172 0.0006689948 0.0006640688 0.000671343 0.0006726441
##             [,12]        [,13]        [,14]        [,15]        [,16]
## [1,] 0.0006733309 0.0006674855 0.0006564296 0.0006518005 0.0006540098
##             [,17]        [,18]        [,19]        [,20]        [,21]
## [1,] 0.0006507567 0.0006459218 0.0006461407 0.0006589831 0.0006674049
##             [,22]        [,23]        [,24]        [,25]        [,26]
## [1,] 0.0006777652 0.000665184 0.0006570319 0.0006627217 0.0006758206
##             [,27]        [,28]        [,29]        [,30]        [,31]
## [1,] 0.0006655444 0.0006768997 0.0006898921 0.000621723 0.0005961709
##            [,32]       [,33]        [,34]       [,35]        [,36]        [,37]
## [1,] 0.000603939 0.000592064 0.0005924387 0.000599938 0.0006047488 0.0006033512
##             [,38]       [,39]        [,40]        [,41]       [,42]
```

```
## [1,] 0.0006326681 0.000623832 0.0006208656 0.0006332516 0.000630886
##             [,43]       [,44]        [,45]        [,46]        [,47]
## [1,] 0.0006383781 0.000639292 0.0006088227 0.0005891676 0.0005971654
##             [,48]        [,49]        [,50]        [,51]        [,52]
## [1,] 0.0005842472 0.0005815843 0.0006227227 0.0005858753 0.0005837615
##             [,53]        [,54]       [,55]       [,56]        [,57]
## [1,] 0.0005717364 0.0005547353 0.000550816 0.000577268 0.0005970309
##             [,58]        [,59]        [,60]        [,61]        [,62]
## [1,] 0.0006066931 0.0006123297 0.0006154445 0.0006128905 0.0006175716
##             [,63]        [,64]        [,65]        [,66]        [,67]
## [1,] 0.0006151847 0.0006180428 0.0006277324 0.0006076812 0.0006105384
##             [,68]        [,69]        [,70]        [,71]        [,72]
## [1,] 0.0006187817 0.0006079826 0.0006009496 0.0006059602 0.0005921597
##             [,73]        [,74]        [,75]        [,76]        [,77]
## [1,] 0.0005924534 0.0005873035 0.0006026131 0.0005932598 0.0005855203
##             [,78]        [,79]        [,80]        [,81]        [,82]
## [1,] 0.0005755917 0.0005772603 0.0006579476 0.0006119431 0.0005976374
##             [,83]        [,84]        [,85]        [,86]        [,87]
## [1,] 0.0005992291 0.0006118728 0.0006297322 0.0006253811 0.0006141249
##             [,88]        [,89]        [,90]        [,91]        [,92]
## [1,] 0.0006220779 0.0006219411 0.0006450074 0.0006540323 0.0006312219
##             [,93]        [,94]        [,95]        [,96]        [,97]
## [1,] 0.0006526538 0.0006591791 0.0006555231 0.0006522951 0.0006356126
##             [,98]        [,99]       [,100]       [,101]       [,102]
## [1,] 0.0006193523 0.0005931111 0.0005898361 0.0006009667 0.0006072181
##            [,103]       [,104]       [,105]       [,106]       [,107]
## [1,] 0.0005834279 0.0005895001 0.0005996829 0.0005913207 0.0005961294
##            [,108]       [,109]       [,110]      [,111]       [,112]
## [1,] 0.0005778481 0.0005770688 0.0005937319 0.000614071 0.0006329584
##            [,113]       [,114]       [,115]       [,116]       [,117]
## [1,] 0.000606761 0.0006162574 0.0005648912 0.0005781285 0.0005940281
##            [,118]       [,119]       [,120]       [,121]       [,122]
## [1,] 0.0005815239 0.0005772093 0.0005712866 0.0005487419 0.0005694749
##            [,123]       [,124]       [,125]       [,126]       [,127]
## [1,] 0.0005774939 0.0005765129 0.0005684108 0.0005640919 0.0005671435
##            [,128]       [,129]       [,130]       [,131]       [,132]
## [1,] 0.0005870433 0.0005761144 0.0005672894 0.0005761575 0.0005889352
##            [,133]       [,134]
## [1,] 0.0005821026 0.0005951188
##
## [[4]]
## integer(0)
```

```
# plot_Global_warming(trop_north, arima_fit = trop_north_fitting_Arimareg)
```

```
plot_Global_warming(trop_south, arima_fit = trop_south_fitting_Arimareg)
```

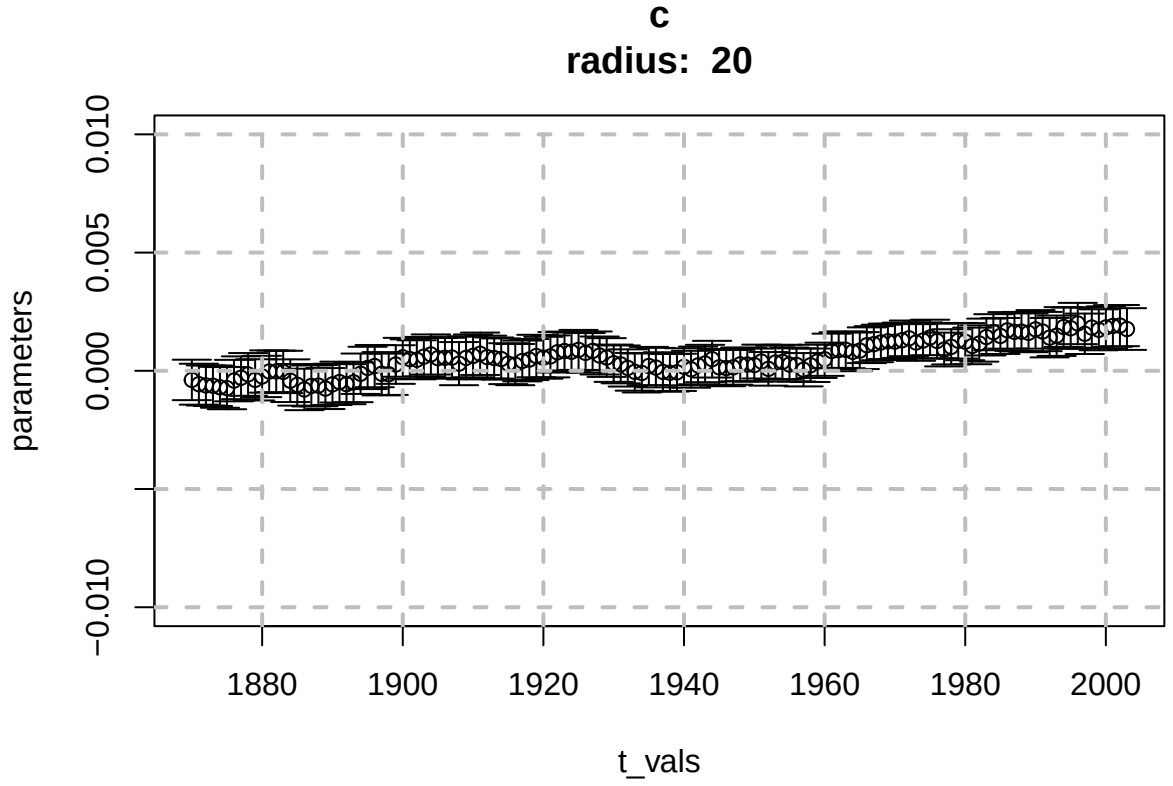



```
## [[1]]
## Series: cutted_data
## Regression with ARIMA(1,0,0)(2,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1    sar2  intercept                      t
##       0.5771  0.4348  0.3794    23.9467  0.6998  2.0017  0.0015
## s.e.  0.0360  0.0403  0.0411     0.3081  0.1909  0.1906  0.0010
##
## sigma^2 = 0.1428:  log likelihood = -233.03
## AIC=482.05   AICc=482.33   BIC=516.03
##
## [[2]]
##              [,1]          [,2]          [,3]          [,4]          [,5]
## [1,] 0.0002813919 -0.0001721633 -0.0004215101 -0.0005676204 -0.0007132148
##               [,6]          [,7]          [,8]          [,9]         [,10]
## [1,] -0.0006124012 -0.0001254455 8.093833e-05 0.0002427998 -0.0002501677
##              [,11]        [,12]        [,13]        [,14]         [,15]
## [1,] -0.0003839291 0.000383922 0.0002430723 4.15334e-06 -0.0004048842
##              [,16]         [,17]         [,18]         [,19]        [,20]
## [1,] -0.0007396881 -0.0004408121 -0.0003647635 -0.0007460857 -0.000999185
##              [,21]         [,22]         [,23]         [,24]         [,25]
## [1,] -0.0004968729 -0.0005265998 -0.0006565648 -0.0006681726 -0.0002278467
##             [,26]        [,27]        [,28]        [,29]         [,30]
## [1,] 0.0001490482 0.000392644 -0.000440744 -0.001383694 -0.0006749332
##              [,31]         [,32]         [,33]         [,34]        [,35]
```

```
## [1,] -0.0001219943 -0.0002213139 -0.0002798146 -7.108498e-05 5.186623e-05
##             [,36]        [,37]        [,38]         [,39]        [,40]
## [1,] -0.000228431 5.796463e-05 0.0001779037 -7.572273e-05 -0.000100446
##            [,41]        [,42]        [,43]        [,44]       [,45]
## [1,] 0.000111904 0.0003175276 0.0005151047 0.0004494152 0.000125335
##            [,46]        [,47]       [,48]        [,49]        [,50]
## [1,] -4.52376e-07 -2.02919e-05 4.74692e-05 0.0004277202 0.0004238236
##            [,51]        [,52]        [,53]        [,54]        [,55]
## [1,] 0.0001326476 0.0003768856 0.0007522419 0.0008505492 0.0008594865
##            [,56]        [,57]        [,58]        [,59]        [,60]
## [1,] 0.0005424907 0.0006042699 0.0009038443 0.0007603453 0.0007492307
##            [,61]        [,62]        [,63]        [,64]         [,65]
## [1,] 0.0004607407 0.0003264771 0.0004036685 0.0003542311 -0.0002426018
##             [,66]        [,67]        [,68]        [,69]        [,70]
## [1,] -9.503417e-06 0.0005642262 0.0004860298 0.0005715263 0.0006193856
##            [,71]        [,72]        [,73]        [,74]       [,75]
## [1,] 0.0006645662 0.0002387627 0.0003711536 0.0002700321 0.000335179
##            [,76]         [,77]      [,78]         [,79]         [,80]
## [1,] 9.913921e-05 -0.0002323992 2.6808e-05 -0.0001216164 -8.231095e-06
##            [,81]        [,82]         [,83]        [,84]        [,85]
## [1,] 0.0001404609 0.0002214132 -9.096222e-05 0.0003411992 0.0005399929
##            [,86]         [,87]         [,88]         [,89]         [,90]
## [1,] 7.144555e-05 -0.0001084332 -0.0004322456 -0.0002321282 -1.131233e-05
##             [,91]        [,92]        [,93]        [,94]        [,95]
## [1,] -6.503325e-06 0.0003001565 0.0004541929 0.0005270473 0.0005021792
##            [,96]        [,97]        [,98]       [,99]      [,100]      [,101]
## [1,] 0.0007166683 0.0004215928 0.0005870539 0.001103537 0.001149646 0.001162519
##           [,102]      [,103]       [,104]      [,105]      [,106]     [,107]
## [1,] 0.001146869 0.001021431 0.0009963201 0.001118397 0.001376667 0.00175903
##           [,108]       [,109]      [,110]     [,111]      [,112]      [,113]
## [1,] 0.001050654 0.0009591412 0.001732035 0.00158087 0.001014273 0.001517925
##         [,114]      [,115]      [,116]     [,117]      [,118]      [,119]
## [1,] 0.0020358 0.002207636 0.001913697 0.00213375 0.002301109 0.002132389
##           [,120]      [,121]      [,122]      [,123]      [,124]      [,125]
## [1,] 0.001745643 0.001872978 0.002224967 0.001664425 0.001565466 0.002541821
##           [,126]      [,127]      [,128]      [,129]      [,130]      [,131]
## [1,] 0.002185288 0.002868118 0.002503743 0.002378459 0.002122694 0.002187319
##           [,132]      [,133]      [,134]
## [1,] 0.002274337 0.002084614 0.001259365
##
## [[3]]
##             [,1]         [,2]         [,3]         [,4]         [,5]
## [1,] 0.0006291827 0.0006751037 0.0007033067 0.0007064172 0.0007179462
##             [,6]         [,7]         [,8]         [,9]        [,10]
## [1,] 0.0007318275 0.0007604575 0.0007261827 0.0007082294 0.0006969577
##            [,11]        [,12]        [,13]        [,14]        [,15]
## [1,] 0.000681366 0.0007144761 0.0006848843 0.0006653475 0.0007079507
##            [,16]        [,17]        [,18]        [,19]        [,20]
## [1,] 0.0007555238 0.0007736898 0.0007940086 0.0008178593 0.0008092768
##            [,21]        [,22]        [,23]        [,24]       [,25]
## [1,] 0.000793337 0.0008045325 0.0008121024 0.0008313807 0.000808346
##            [,26]        [,27]        [,28]      [,29]      [,30]       [,31]
## [1,] 0.0008391493 0.0008819666 0.0009486528 0.00105926 0.00103681 0.001091307
##            [,32]       [,33]       [,34]       [,35]       [,36]       [,37]
```

```
## [1,] 0.001079473 0.001049058 0.001046197 0.001053858 0.001057669 0.001020856
##           [,38]       [,39]       [,40]       [,41]       [,42]        [,43]
## [1,] 0.00107019 0.001067343 0.001062811 0.001046672 0.001000425 0.0009630823
##             [,44]        [,45]        [,46]        [,47]        [,48]
## [1,] 0.0009626672 0.0009781738 0.0009228349 0.0009226214 0.0009317908
##             [,49]        [,50]        [,51]        [,52]        [,53]
## [1,] 0.0008909678 0.0009362308 0.0008913681 0.0008716932 0.0008546646
##             [,54]        [,55]       [,56]        [,57]        [,58]
## [1,] 0.0008138143 0.0008008055 0.000800185 0.0007979134 0.0007685706
##             [,59]        [,60]        [,61]        [,62]        [,63]
## [1,] 0.0007567637 0.0007620934 0.0007548435 0.0007693808 0.0007709533
##             [,64]        [,65]        [,66]        [,67]       [,68]
## [1,] 0.0007619399 0.0007573803 0.0007594604 0.0006926387 0.000689279
##             [,69]        [,70]        [,71]        [,72]        [,73]
## [1,] 0.0006741269 0.0006722204 0.0006791928 0.0006874013 0.0007071535
##             [,74]        [,75]        [,76]        [,77]        [,78]
## [1,] 0.0007065437 0.0007003362 0.0007243314 0.0007067542 0.0006798621
##             [,79]        [,80]        [,81]        [,82]        [,83]
## [1,] 0.0006891583 0.0007003147 0.0006742838 0.0006878523 0.0007033143
##             [,84]        [,85]        [,86]        [,87]        [,88]
## [1,] 0.0006971659 0.0007754021 0.0008060805 0.0008080135 0.0008000939
##             [,89]        [,90]        [,91]        [,92]        [,93]
## [1,] 0.0008036903 0.0008239816 0.0008513242 0.0009023634 0.0008968738
##             [,94]        [,95]        [,96]        [,97]        [,98]
## [1,] 0.0009003218 0.0009586493 0.0009527249 0.0009441396 0.0009240483
##             [,99]       [,100]       [,101]       [,102]       [,103]
## [1,] 0.0009176777 0.0009384702 0.0009661613 0.0009628129 0.0009185657
##            [,104]       [,105]       [,106]       [,107]       [,108]
## [1,] 0.0009528043 0.0009303167 0.0009162767 0.0009198901 0.0008690322
##            [,109]       [,110]       [,111]       [,112]      [,113]
## [1,] 0.0008643506 0.0009252824 0.0009430082 0.0009838575 0.000952973
##            [,114]       [,115]       [,116]      [,117]      [,118]      [,119]
## [1,] 0.0009731163 0.0009225704 0.0009399419 0.001004664 0.001000892 0.001015227
##           [,120]       [,121]      [,122]      [,123]     [,124]       [,125]
## [1,] 0.001011619 0.0009832954 0.001015903 0.001035392 0.00101822 0.0009447798
##            [,126]       [,127]       [,128]       [,129]      [,130]
## [1,] 0.0009546444 0.0009536538 0.0009823921 0.0009847351 0.001004252
##           [,131]       [,132]      [,133]     [,134]
## [1,] 0.001005597 0.0009985336 0.001041947 0.00109825
##
## [[4]]
## integer(0)
```

```
plot_Global_warming(south, arima_fit = south_fitting_Arimareg)
```




```
## [[1]]
## Series: cutted_data
## Regression with ARIMA(1,0,0)(2,0,0)[12] errors
##
## Coefficients:
##          ar1    sar1    sar2  intercept                      t
##       0.2979  0.2822  0.2502    16.9605  3.1644  5.2073  0.0014
## s.e.  0.0422  0.0427  0.0434     0.1252  0.0864  0.0863  0.0004
##
## sigma^2 = 0.2638:  log likelihood = -387.37
## AIC=790.74   AICc=791.02   BIC=824.72
##
## [[2]]
##                [,1]          [,2]          [,3]          [,4]          [,5]
## [1,] -0.0003862024 -0.0005667776 -0.0006195325 -0.0006320142 -0.0006980677
##                [,6]          [,7]          [,8]          [,9]         [,10]
## [1,] -0.0007344119 -0.0004139917 -0.0002947499 -0.0001531954 -0.0003830842
##               [,11]         [,12]         [,13]         [,14]         [,15]
## [1,] -0.0002392565 -3.039357e-05 -2.375076e-05 -4.838799e-05 -0.0004187197
##               [,16]         [,17]         [,18]         [,19]         [,20]
## [1,] -0.0005942234 -0.0007880843 -0.0006401642 -0.0006260948 -0.0007514938
##               [,21]         [,22]         [,23]         [,24]         [,25]
## [1,] -0.00057448 -0.0004783505 -0.0005658317 -0.0004848612 -0.0001238945
##               [,26]         [,27]         [,28]         [,29]         [,30]
## [1,] 0.0001212164 0.0001983186 -0.0001249924 -0.0001464065 0.0002646041
##               [,31]         [,32]         [,33]         [,34]         [,35]
```

```
## [1,] 0.0005713077 0.0004967146 0.0004654423 0.000598377 0.0006903351
##             [,36]        [,37]       [,38]       [,39]        [,40]
## [1,] 0.0005349088 0.0005514607 0.000557757 0.000302887 0.0005464206
##             [,41]        [,42]        [,43]        [,44]        [,45]
## [1,] 0.0006304678 0.0007208343 0.0005795274 0.0005390997 0.0004969853
##             [,46]        [,47]        [,48]        [,49]        [,50]
## [1,] 0.0003017951 0.0002620825 0.0004151333 0.0004746726 0.0006244811
##             [,51]        [,52]        [,53]        [,54]        [,55]
## [1,] 0.0005513729 0.0006093927 0.0007831915 0.0008341985 0.0008053259
##             [,56]        [,57]        [,58]        [,59]        [,60]
## [1,] 0.0008836445 0.0007579985 0.0008406302 0.0006463668 0.0005610136
##             [,61]        [,62]        [,63]         [,64]         [,65]
## [1,] 0.0003202015 0.0002706319 0.0001211073 -4.240278e-05 -9.239726e-05
##             [,66]        [,67]         [,68]         [,69]         [,70]
## [1,] 0.0002026821 0.0001347463 -4.706007e-05 -8.203568e-05 -6.437713e-05
##             [,71]        [,72]        [,73]        [,74]        [,75]
## [1,] 0.0001694343 6.566289e-05 0.0002259489 0.0003086674 0.0004904454
##             [,76]        [,77]        [,78]        [,79]        [,80]
## [1,] 0.0001483078 0.0001147127 0.0001475008 0.0002707367 0.0002631794
##             [,81]        [,82]        [,83]        [,84]        [,85]
## [1,] 0.0002417586 0.0003906583 8.221615e-05 0.0003496613 0.0003762817
##             [,86]        [,87]        [,88]        [,89]        [,90]
## [1,] 0.0002642713 0.0002478471 4.502116e-05 0.0002348242 0.0003997482
##             [,91]        [,92]        [,93]        [,94]        [,95]
## [1,] 0.0004883264 0.0008387232 0.0008773984 0.0008891317 0.0008019116
##             [,96]       [,97]       [,98]       [,99]      [,100]      [,101]
## [1,] 0.0008541923 0.001080992 0.001125919 0.001198272 0.001246812 0.001233508
##           [,102]      [,103]      [,104]      [,105]      [,106]      [,107]
## [1,] 0.001291825 0.001372695 0.001197238 0.001279567 0.001410643 0.001261413
##           [,108]      [,109]      [,110]      [,111]      [,112]      [,113]
## [1,] 0.0008994161 0.001012781 0.001271365 0.001231611 0.001051885 0.001154682
##           [,114]      [,115]      [,116]      [,117]      [,118]      [,119]
## [1,] 0.001427583 0.001631776 0.001474197 0.001708986 0.001647073 0.001654683
##           [,120]     [,121]      [,122]      [,123]      [,124]      [,125]
## [1,] 0.001606023 0.00175182 0.001659885 0.001401994 0.001482973 0.001850753
##           [,126]      [,127]     [,128]     [,129]      [,130]      [,131]
## [1,] 0.001800162 0.002000028 0.00156583 0.00182708 0.001733735 0.001833099
##           [,132]      [,133]      [,134]
## [1,] 0.001897054 0.001911828 0.001766063
##
## [[3]]
##             [,1]         [,2]         [,3]         [,4]         [,5]
## [1,] 0.0004277668 0.0004330497 0.0004244277 0.0004280169 0.0004318196
##             [,6]         [,7]        [,8]         [,9]        [,10]
## [1,] 0.0004456766 0.0004384643 0.000452566 0.0004517793 0.0004357215
##             [,11]        [,12]       [,13]        [,14]        [,15]
## [1,] 0.0004367133 0.0004463323 0.000439583 0.0004473062 0.0004514774
##           [,16]       [,17]        [,18]      [,19]        [,20]       [,21]
## [1,] 0.000439552 0.000438212 0.0004327571 0.00043623 0.0004330489 0.000435759
##           [,22]        [,23]       [,24]       [,25]        [,26]        [,27]
## [1,] 0.000431991 0.0004234022 0.000421268 0.000426871 0.0004476402 0.0004465381
##             [,28]        [,29]        [,30]        [,31]        [,32]
## [1,] 0.0004575539 0.0004365853 0.0004082237 0.0004106423 0.0004166553
##             [,33]        [,34]        [,35]        [,36]        [,37]
```

```
## [1,] 0.0004124561 0.0004174699 0.0004241462 0.0004252129 0.0004218384
##             [,38]        [,39]        [,40]        [,41]        [,42]
## [1,] 0.0004441416 0.0004558816 0.0004546622 0.0004526512 0.0004479073
##             [,43]        [,44]        [,45]        [,46]        [,47]
## [1,] 0.0004534419 0.0004354715 0.0004358649 0.0004329781 0.0004353915
##             [,48]        [,49]        [,50]        [,51]        [,52]
## [1,] 0.0004315328 0.0004340626 0.0004490486 0.0004431837 0.0004438309
##             [,53]       [,54]       [,55]        [,56]        [,57]
## [1,] 0.0004284726 0.000412092 0.000405969 0.0004227267 0.0004188428
##             [,58]        [,59]        [,60]        [,61]        [,62]
## [1,] 0.0004109976 0.0004014151 0.0004094842 0.0003939995 0.0004003003
##             [,63]        [,64]        [,65]        [,66]        [,67]
## [1,] 0.0003929894 0.0003990511 0.0004124485 0.0004036714 0.0004170881
##             [,68]        [,69]       [,70]        [,71]        [,72]
## [1,] 0.0004147541 0.0003965628 0.000393328 0.0003918712 0.0003902141
##            [,73]        [,74]        [,75]        [,76]        [,77]
## [1,] 0.000398256 0.0003949913 0.0003877878 0.0003879933 0.0003832576
##             [,78]        [,79]        [,80]        [,81]        [,82]
## [1,] 0.0003673682 0.0003572066 0.0003529765 0.0003490812 0.0003580606
##             [,83]        [,84]        [,85]        [,86]        [,87]
## [1,] 0.0003552503 0.0003571678 0.0003628293 0.0003596475 0.000350487
##             [,88]        [,89]        [,90]        [,91]        [,92]
## [1,] 0.0003526202 0.0003534088 0.0003512574 0.0003515311 0.0003659362
##             [,93]        [,94]       [,95]        [,96]        [,97]
## [1,] 0.0003769513 0.0003899821 0.000409145 0.000390337 0.0003773333
##             [,98]        [,99]       [,100]       [,101]       [,102]
## [1,] 0.0003809948 0.0003754708 0.0003751286 0.0003768386 0.0003734261
##            [,103]       [,104]       [,105]       [,106]       [,107]
## [1,] 0.0003766958 0.0003878458 0.0003835627 0.0003748653 0.0003655626
##            [,108]       [,109]       [,110]       [,111]       [,112]
## [1,] 0.0003565639 0.0003713947 0.0003766838 0.0003925649 0.000386763
##            [,113]       [,114]       [,115]       [,116]       [,117]
## [1,] 0.0003836911 0.0003897854 0.0003811519 0.0003807604 0.0003860731
##           [,118]       [,119]       [,120]       [,121]       [,122]
## [1,] 0.000403116 0.0004174497 0.0004101493 0.0004073566 0.0004151798
##           [,123]       [,124]       [,125]       [,126]       [,127]
## [1,] 0.000417499 0.0004260949 0.0004207953 0.0004371851 0.0004364249
##            [,128]       [,129]       [,130]       [,131]       [,132]
## [1,] 0.0004273705 0.0004249747 0.0004328561 0.0004465895 0.0004396364
##            [,133]       [,134]
## [1,] 0.0004352493 0.0004410023
##
## [[4]]
## integer(0)
```

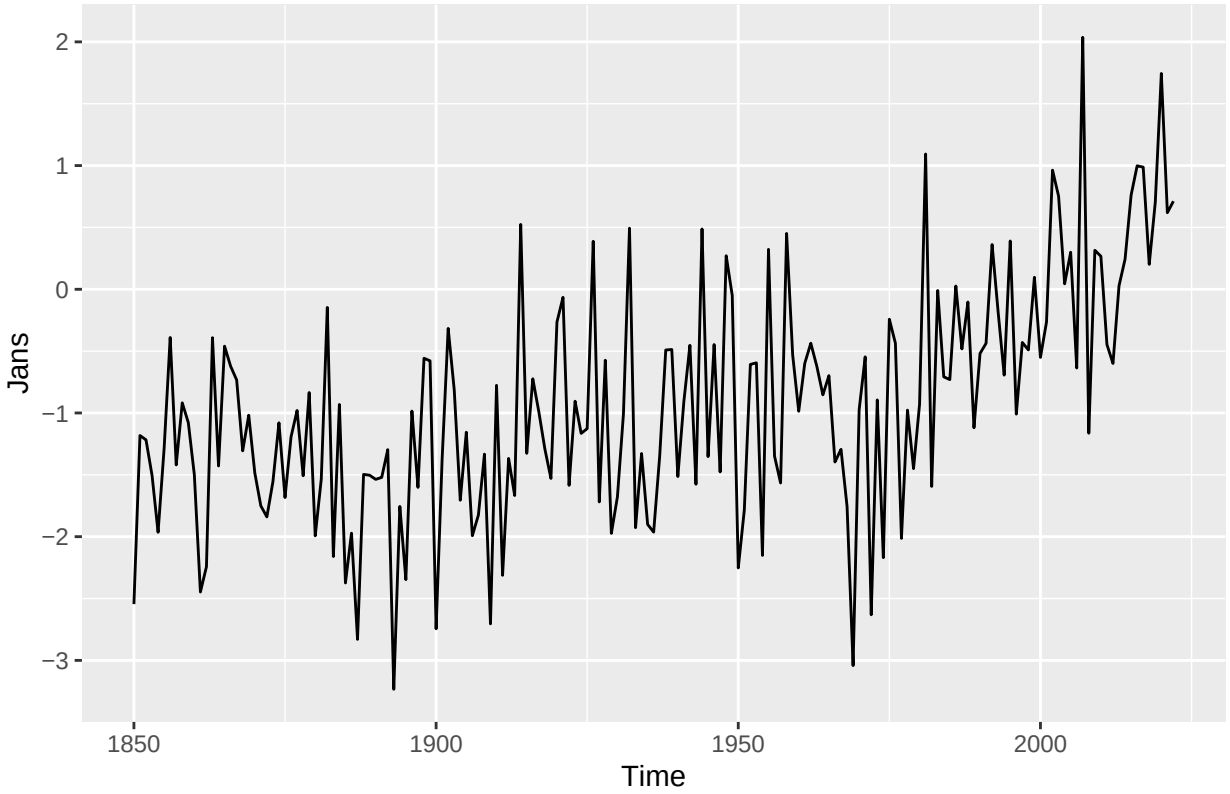
Separating Months:

```
MonthsSeparatedData = read.csv("C:/Users/ss/Desktop/Time_series_Analysis/NorthTemperetures_LandOnly_sep
Jans = ts(data = MonthsSeparatedData[, 1], start = c(1850), end = c(2022), frequency = 1)
Febs = ts(data = MonthsSeparatedData[, 2], start = c(1850), end = c(2022), frequency = 1)
Mars = ts(data = MonthsSeparatedData[, 3], start = c(1850), end = c(2022), frequency = 1)
```

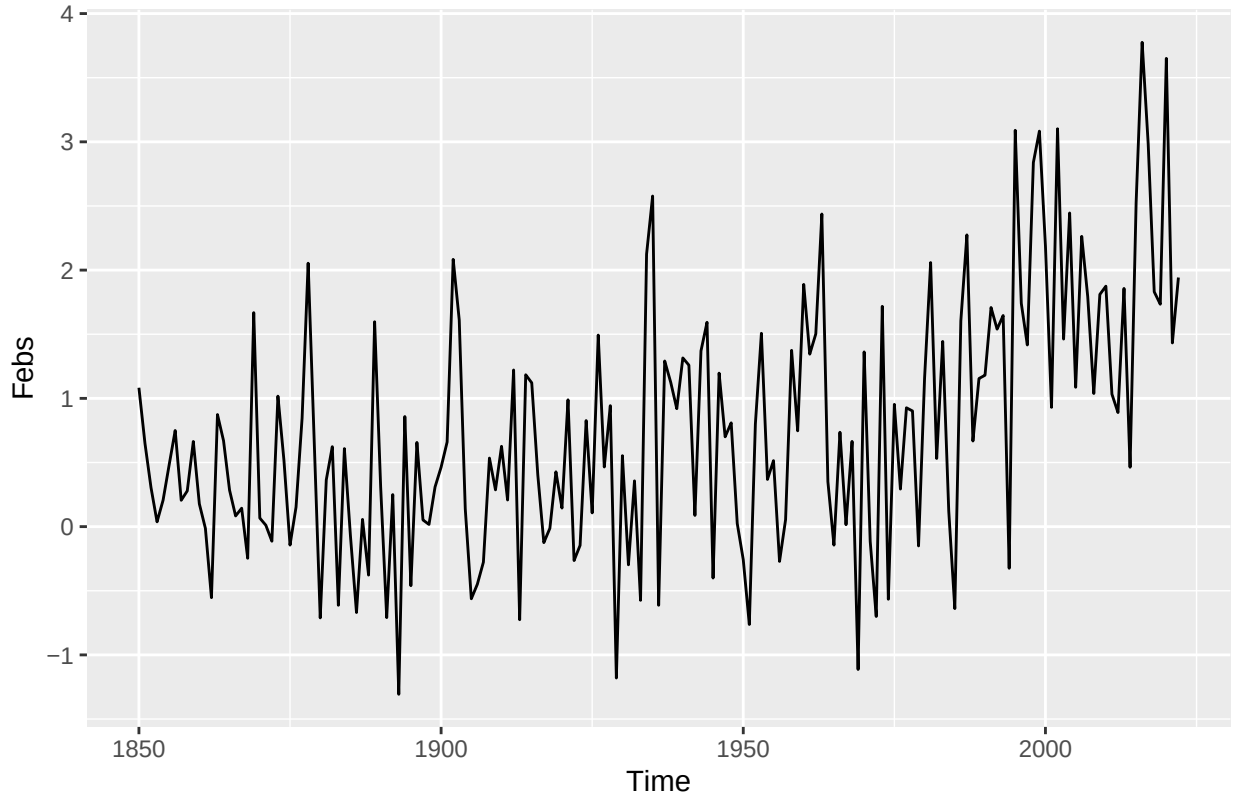
```
Aprs = ts(data = MonthsSeparatedData[, 4], start = c(1850), end = c(2022), frequency = 1)
Mays = ts(data = MonthsSeparatedData[, 5], start = c(1850), end = c(2022), frequency = 1)
Juns = ts(data = MonthsSeparatedData[, 6], start = c(1850), end = c(2022), frequency = 1)
Juls = ts(data = MonthsSeparatedData[, 7], start = c(1850), end = c(2022), frequency = 1)
Augs = ts(data = MonthsSeparatedData[, 8], start = c(1850), end = c(2022), frequency = 1)
Seps = ts(data = MonthsSeparatedData[, 9], start = c(1850), end = c(2022), frequency = 1)
Octs = ts(data = MonthsSeparatedData[, 10], start = c(1850), end = c(2022), frequency = 1)
Novs = ts(data = MonthsSeparatedData[, 11], start = c(1850), end = c(2022), frequency = 1)
Decs = ts(data = MonthsSeparatedData[, 12], start = c(1850), end = c(2022), frequency = 1)
```

Plotting

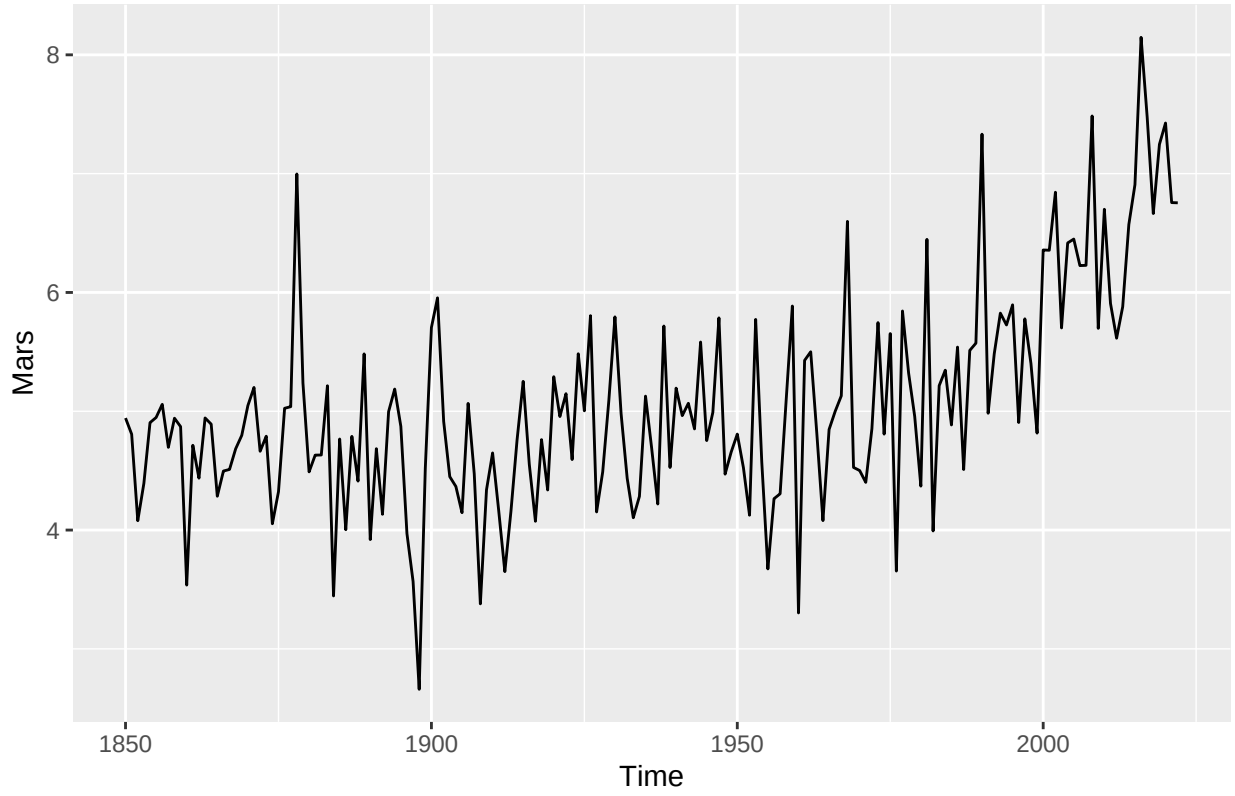
```
library(ggplot2)
library(gridExtra)


plot1 <- autoplot(Jans)

plot2 <- autoplot(Febs)

plot3 <- autoplot(Mars)

plot4 <- autoplot(Aprs)

plot5 <- autoplot(Mays)

plot6 <- autoplot(Juns)

plot7 <-autoplot(Juls)

plot8 <- autoplot(Augs)

plot9 <- autoplot(Seps)

plot10 <- autoplot(Octs)

plot11 <- autoplot(Novs)

plot12 <- autoplot(Decs)



par(mfrow = c(2, 6))
plot(plot1)
```



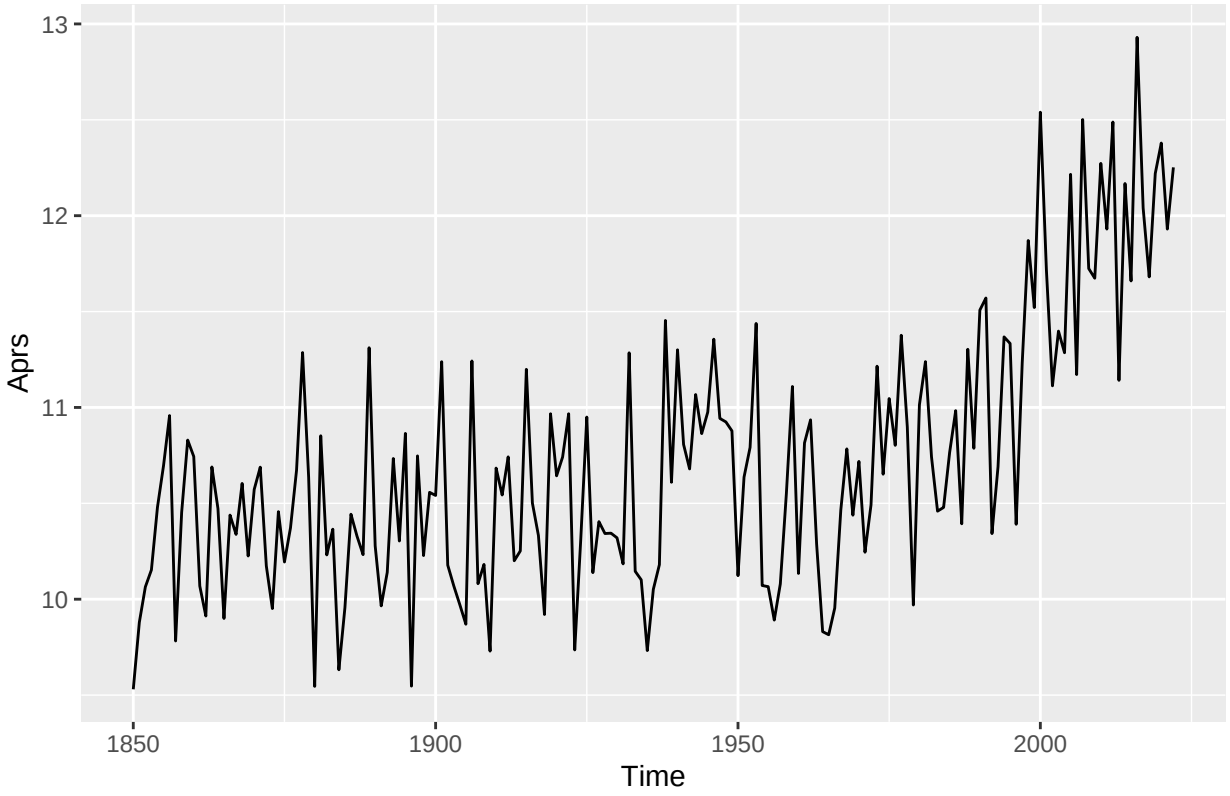

```
plot(plot2)
```



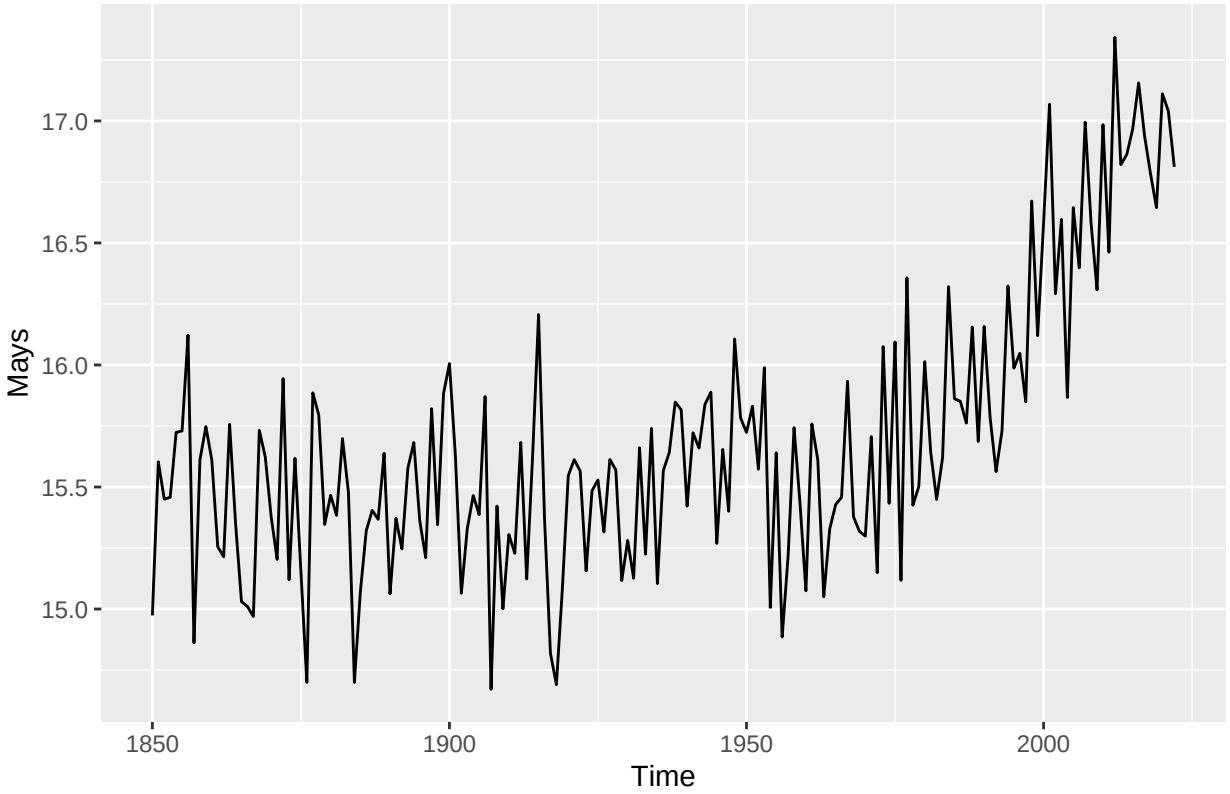

```
plot(plot3)
```



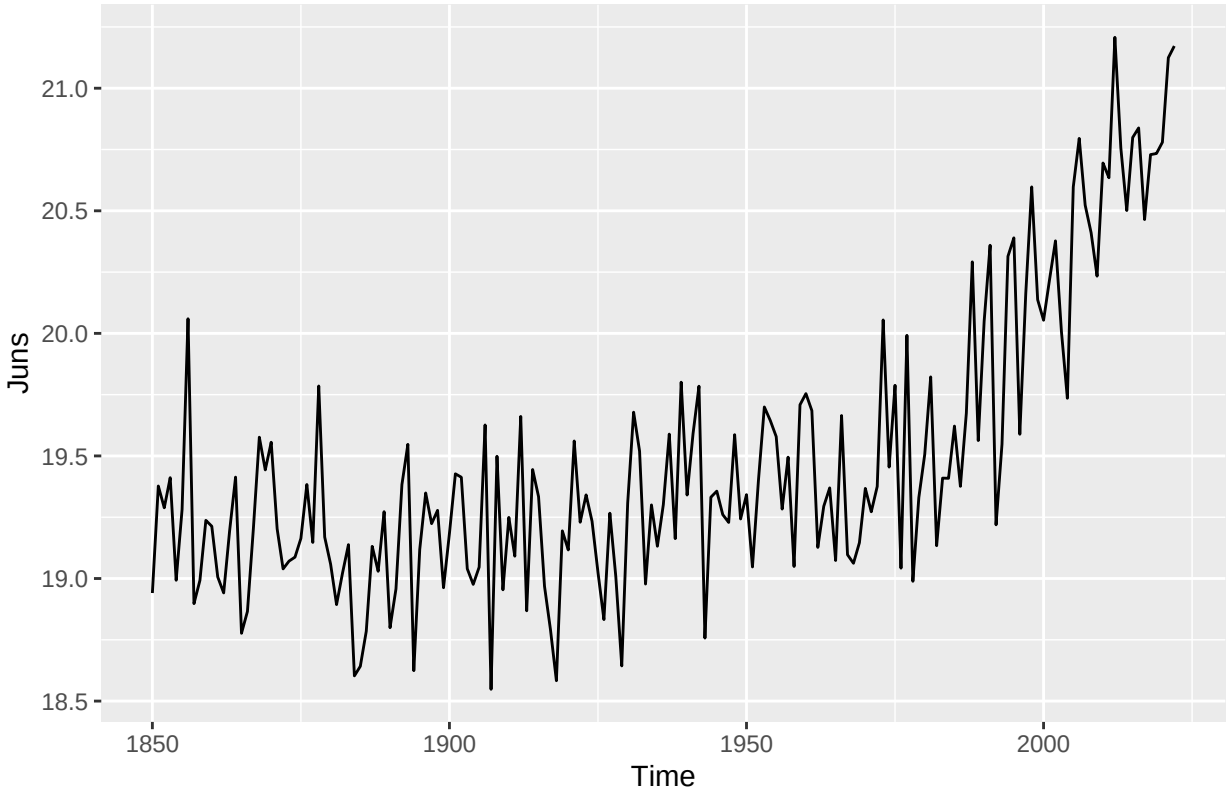

```
plot(plot4)
```



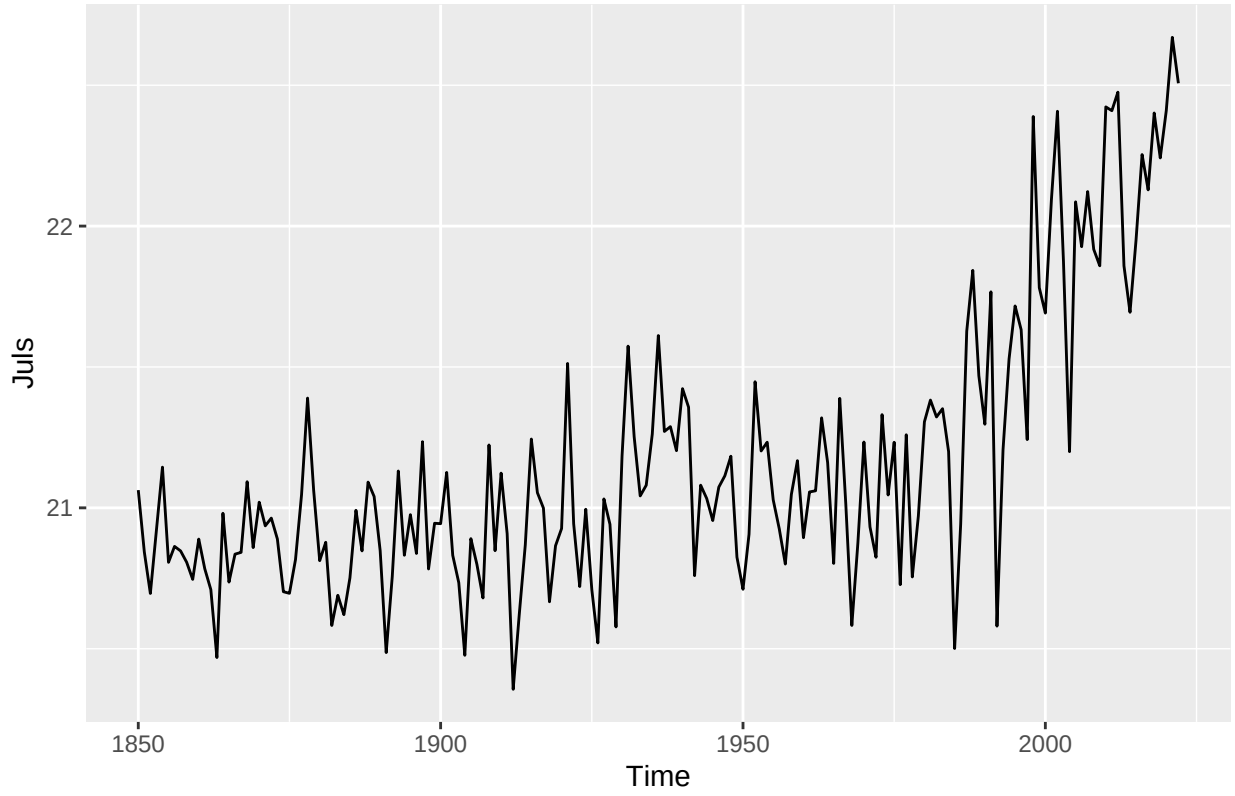

```
plot(plot5)
```



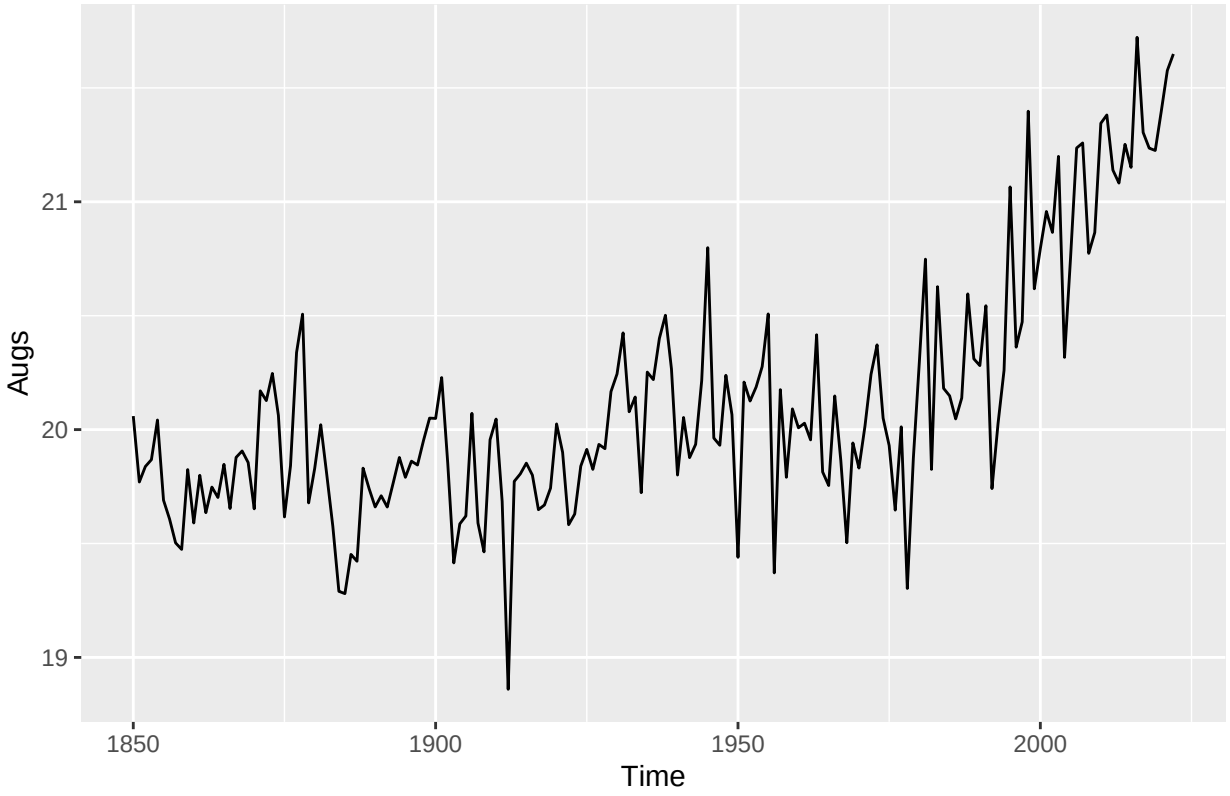

```
plot(plot6)
```



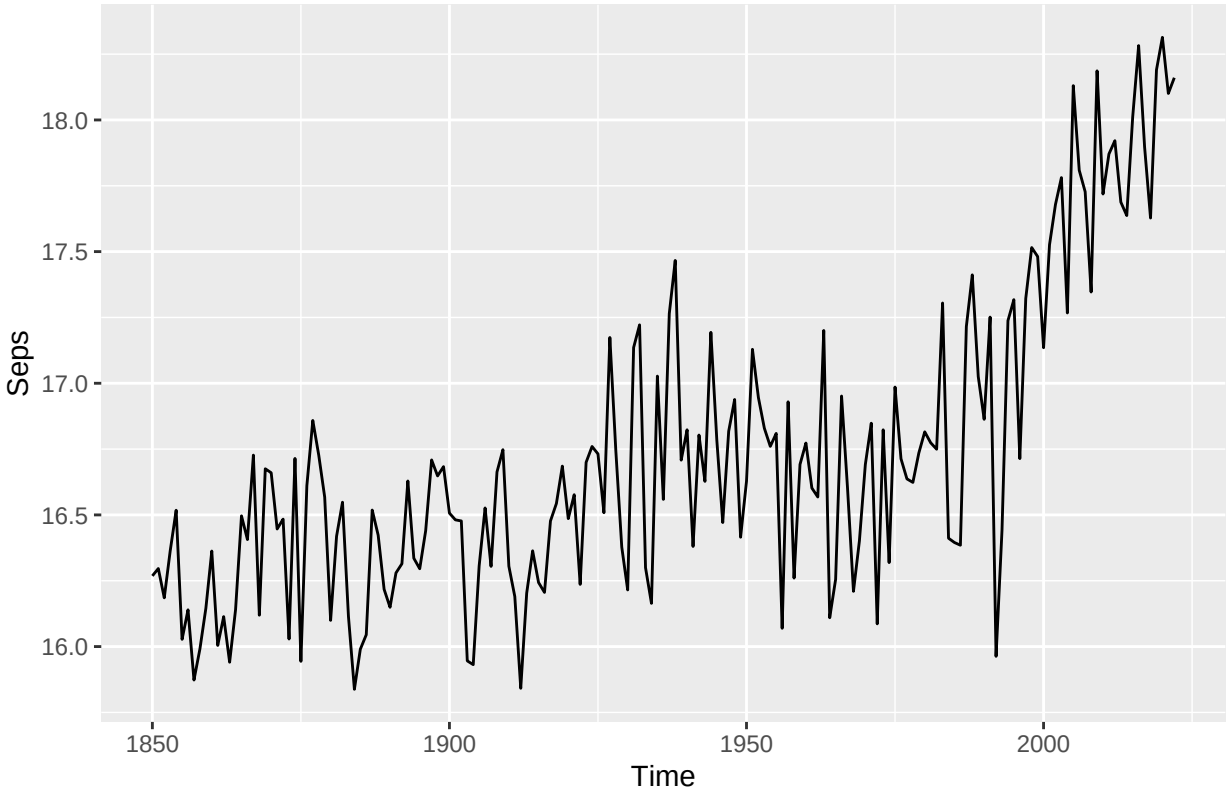

```
plot(plot7)
```



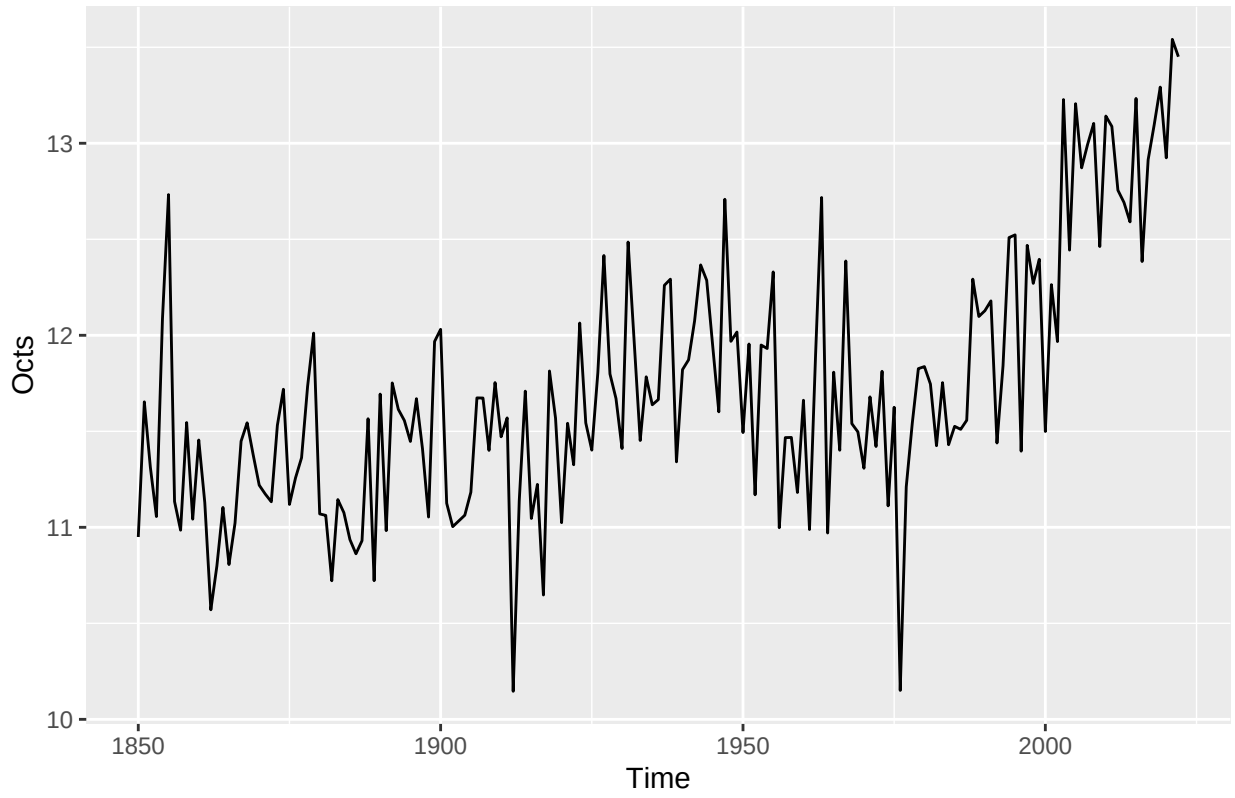

```
plot(plot8)
```



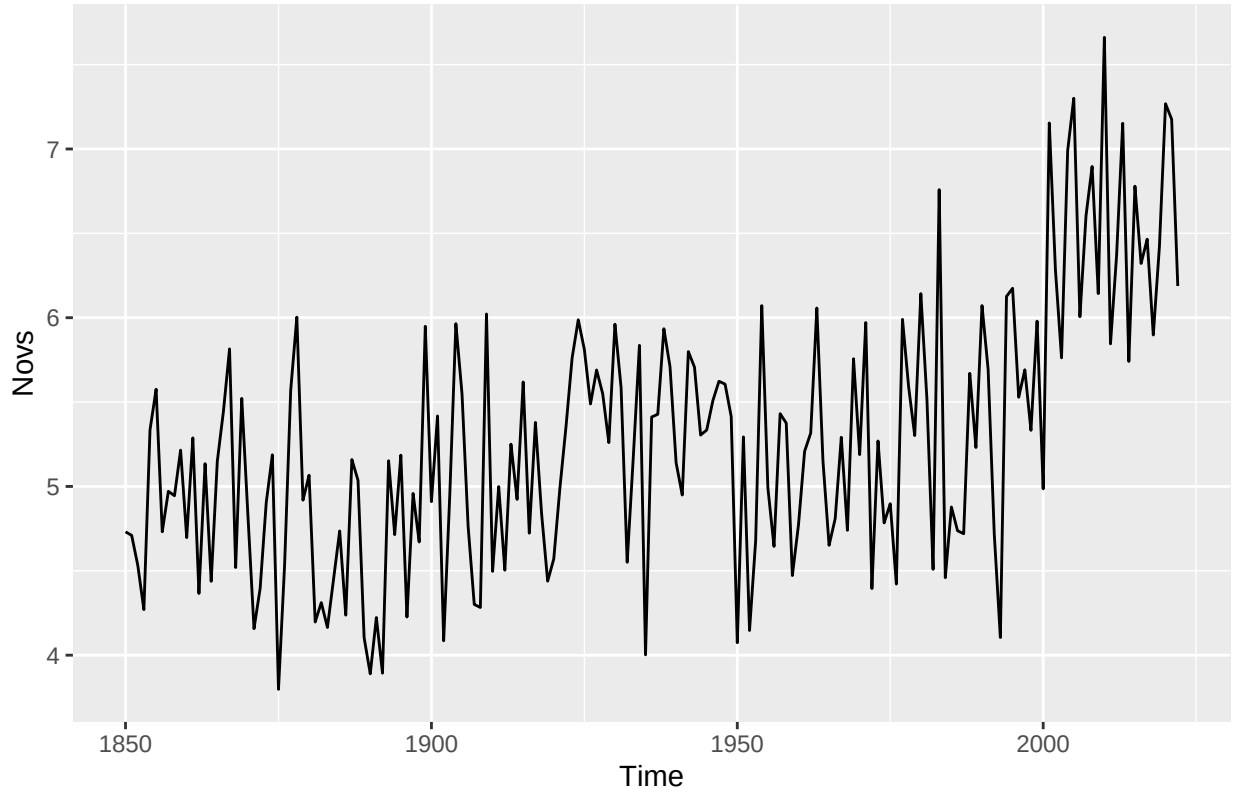

```
plot(plot9)
```



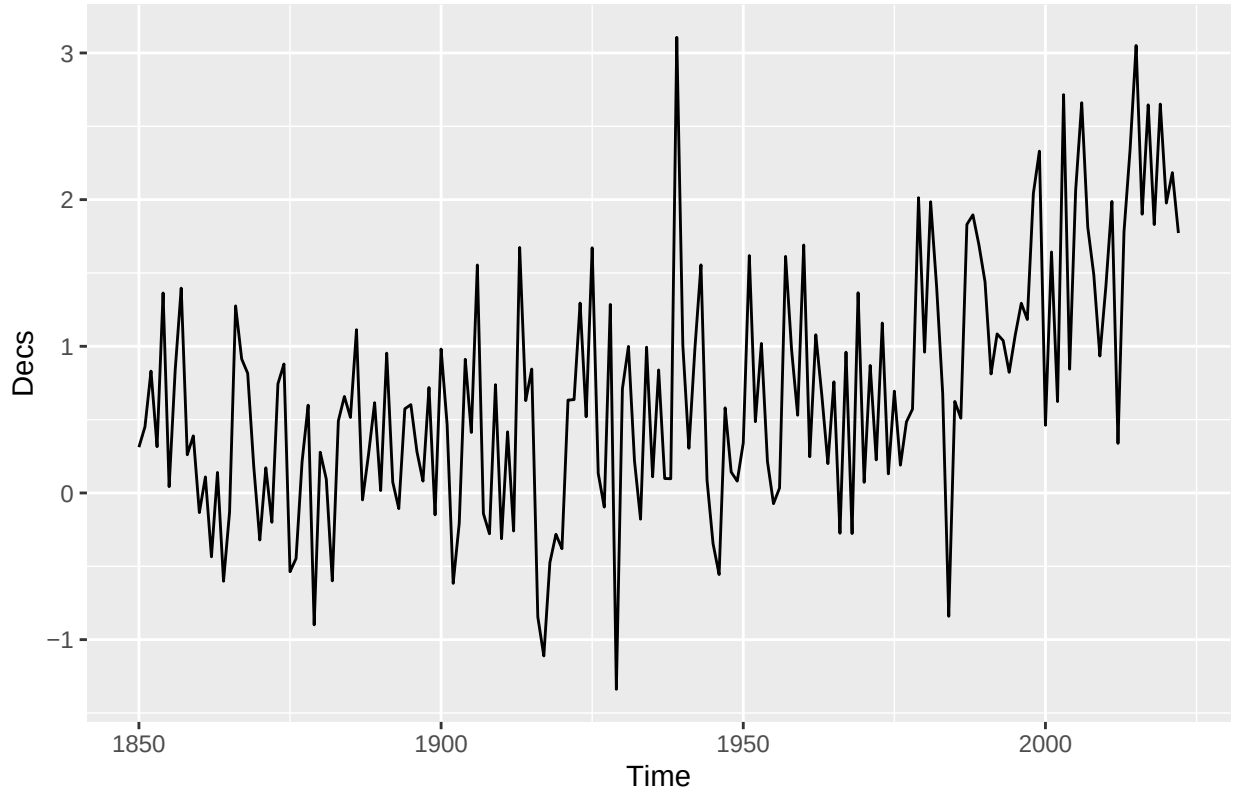

```
plot(plot10)
```



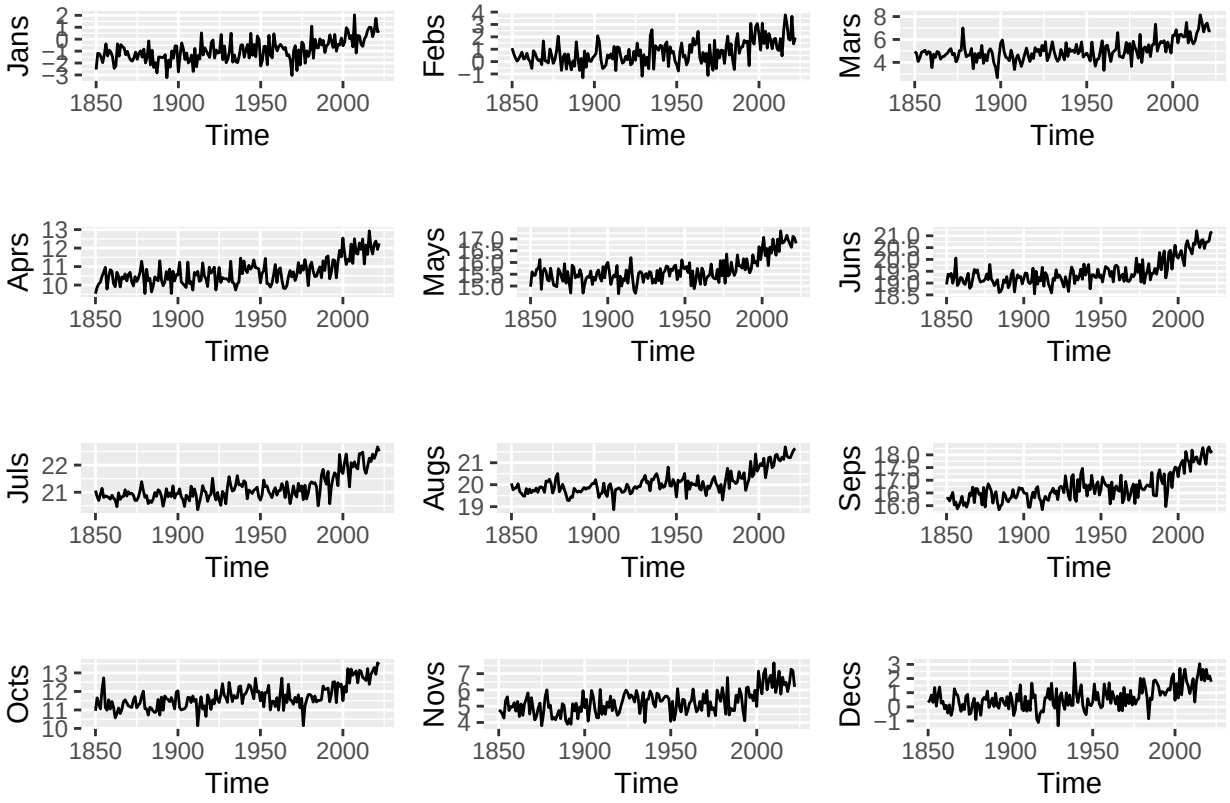

```
plot(plot11)
```



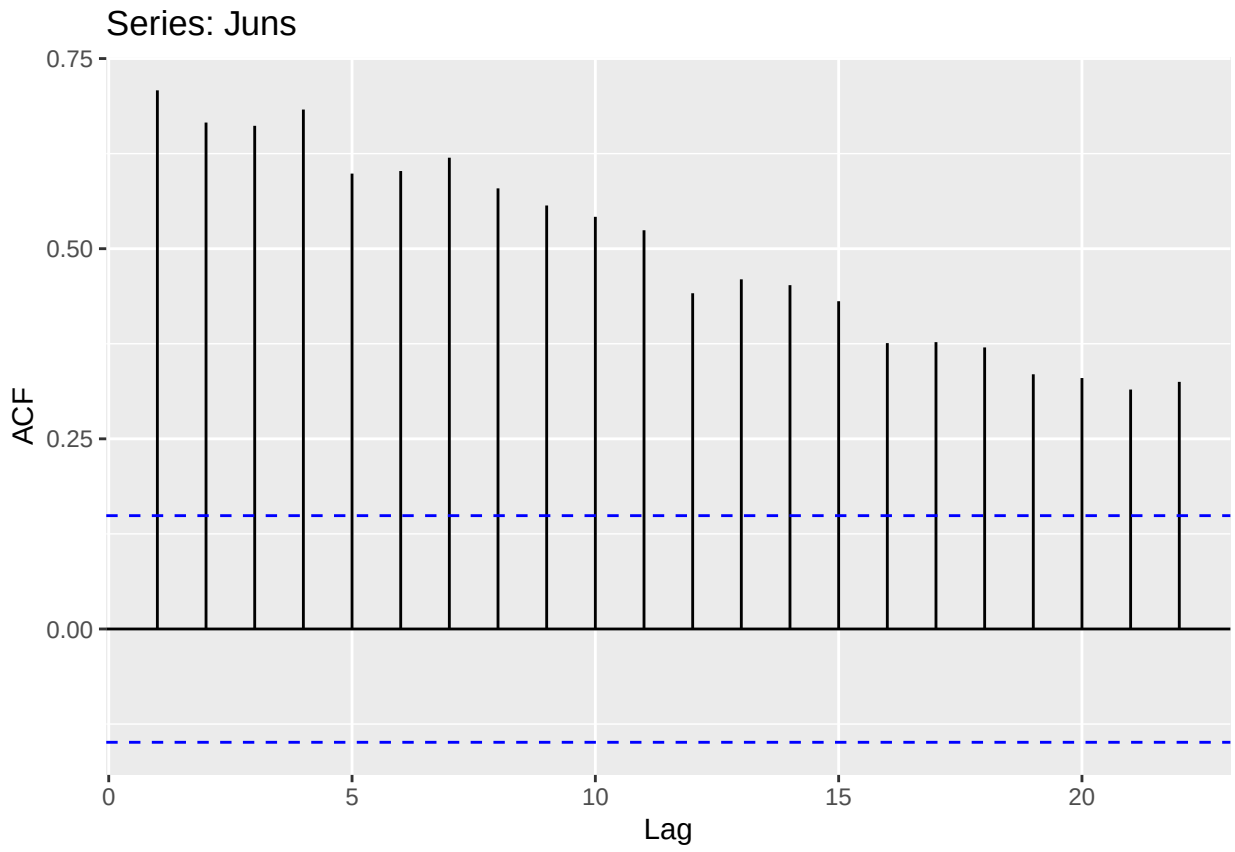

```
plot(plot12)
```




```
layout(matrix(c(c(1, 2, 3, 4, 5, 6), c(1, 2, 3, 4, 5, 6)), nrow = 2))
grid.arrange(plot1, plot2, plot3, plot4, plot5, plot6, plot7, plot8, plot9, plot10, plot11, plot12)
```

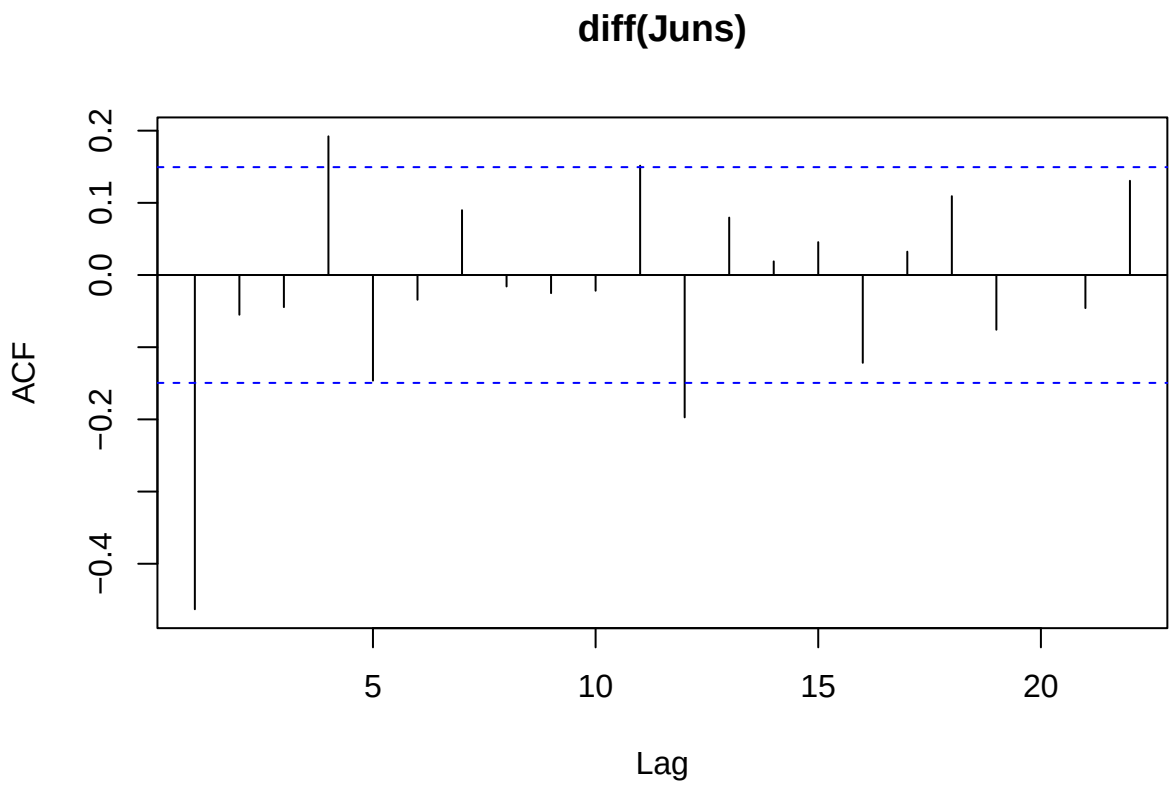

Jans
Febs
Mars
Aprs
Mays
Juns
Juls
Augs
Seps
Octs
Novs
Decs
Time
1850
1900
1950
2000

```
ggAcf(Juns)
```



There is no apparent seasonality in this figure.

```
Acf(diff(Juns))
```



the acf of the differenced data seems to suggest cyclic rather than seasonal behavior.

```
JansArimaFit = auto.arima(Jans, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(JansArimaFit)
```

```
## Series: Jans
## ARIMA(1,1,1) with drift
##
## Coefficients:
##           ar1      ma1   drift
##       -0.1493  -0.8583  0.0128
## s.e.   0.0871   0.0510  0.0074
##
## sigma^2 = 0.5859:  log likelihood = -197.37
## AIC=402.75   AICc=402.99   BIC=415.34
##
## Training set error measures:
##                      ME      RMSE       MAE       MPE     MAPE      MASE
## Training set 0.0110921 0.7565671 0.5858128 -36.01011 159.0192 0.6905222
##                      ACF1
## Training set 0.007772005
```

```
FebsArimaFit = auto.arima(Febs, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(FebsArimaFit)
```

```
## Series: Febs
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.9114  0.0103
## s.e.   0.0340  0.0060
##
## sigma^2 = 0.6975:  log likelihood = -212.95
## AIC=431.91   AICc=432.05   BIC=441.35
##
## Training set error measures:
##                       ME      RMSE       MAE       MPE     MAPE      MASE
## Training set -0.01571603 0.8278734 0.6613522 -14.84503 267.8702 0.7310104
##                      ACF1
## Training set -0.01836561
```

```
MarsArimaFit = auto.arima(Mars, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(MarsArimaFit)
```

```
## Series: Mars
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.8703  0.0132
## s.e.   0.0335  0.0070
##
## sigma^2 = 0.4677:  log likelihood = -178.4
## AIC=362.81   AICc=362.95   BIC=372.25
##
## Training set error measures:
##                        ME      RMSE       MAE       MPE    MAPE      MASE
## Training set -0.004834004 0.6779242 0.5199041 -2.143945 10.7592 0.7522966
##                     ACF1
## Training set 0.02629492
```

```
AprsArimaFit = auto.arima(Aprs, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(AprsArimaFit)
```

```
## Series: Aprs
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.8476  0.0117
## s.e.   0.0384  0.0057
##
## sigma^2 = 0.2268:  log likelihood = -116.1
## AIC=238.21   AICc=238.35   BIC=247.65
##
```

```
## Training set error measures:
##                       ME      RMSE       MAE        MPE     MAPE      MASE
## Training set 0.008983057 0.4721324 0.3804977 -0.1125769 3.557137 0.7598155
##                     ACF1
## Training set 0.005058108
```

```
MaysArimaFit = auto.arima(Mays, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(MaysArimaFit)
```

```
## Series: Mays
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.8269  0.0088
## s.e.   0.0361  0.0047
##
## sigma^2 = 0.1217:  log likelihood = -62.47
## AIC=130.94   AICc=131.09   BIC=140.39
##
## Training set error measures:
##                       ME      RMSE       MAE         MPE     MAPE      MASE
## Training set 0.00413058 0.3457741 0.2742007 -0.0269963 1.753041 0.7181208
##                     ACF1
## Training set -0.08545753
```

```
JunsArimaFit = auto.arima(Juns, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(JunsArimaFit)
```

```
## Series: Juns
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.8155  0.0099
## s.e.   0.0376  0.0046
##
## sigma^2 = 0.1032:  log likelihood = -48.32
## AIC=102.64   AICc=102.78   BIC=112.08
##
## Training set error measures:
##                       ME      RMSE       MAE          MPE     MAPE      MASE
## Training set 0.001558295 0.3185169 0.2572943 -0.02350401 1.320322 0.7826297
##                     ACF1
## Training set -0.02033545
```

```
JulsArimaFit = auto.arima(Juls, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(JulsArimaFit)
```

```
## Series: Juls
## ARIMA(2,1,3) with drift
##
## Coefficients:
##           ar1      ar2      ma1     ma2      ma3   drift
##       -0.5647  -0.7565  -0.0465  0.1807  -0.6642  0.0087
## s.e.   0.1970   0.1001   0.2045  0.1405   0.0860  0.0042
##
## sigma^2 = 0.07248:  log likelihood = -15.97
## AIC=45.94   AICc=46.62   BIC=67.97
##
## Training set error measures:
##                       ME      RMSE      MAE         MPE      MAPE      MASE
## Training set -0.00239044 0.2637244 0.202831 -0.02939569 0.9569008 0.7733554
##                      ACF1
## Training set -0.005294799
```

```
AugsArimaFit = auto.arima(Augs, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(AugsArimaFit)
```

```
## Series: Augs
## ARIMA(1,1,4) with drift
##
## Coefficients:
##           ar1     ma1      ma2      ma3     ma4   drift
##       -0.9786  0.3522  -0.8382  -0.1476  0.1322  0.0095
## s.e.   0.0206  0.0801   0.0842   0.0773  0.0780  0.0056
##
## sigma^2 = 0.08564:  log likelihood = -30.27
## AIC=74.55   AICc=75.23   BIC=96.58
##
## Training set error measures:
##                        ME      RMSE       MAE         MPE     MAPE      MASE
## Training set -0.002424953 0.2866674 0.2192102 -0.03478599 1.090164 0.8227108
##                      ACF1
## Training set 0.0006727474
```

```
SepsArimaFit = auto.arima(Seps, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(SepsArimaFit)
```

```
## Series: Seps
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.7947  0.0110
## s.e.   0.0426  0.0052
##
## sigma^2 = 0.1059:  log likelihood = -50.5
## AIC=106.99   AICc=107.14   BIC=116.44
##
```

```
## Training set error measures:
##                       ME      RMSE       MAE         MPE     MAPE      MASE
## Training set -0.001484166 0.3226627 0.2570461 -0.05032407 1.538747 0.8237334
##                     ACF1
## Training set 0.04863152
```

```
OctsArimaFit = auto.arima(Octs, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(OctsArimaFit)
```

```
## Series: Octs
## ARIMA(0,1,1)
##
## Coefficients:
##           ma1
##       -0.7759
## s.e.   0.0465
##
## sigma^2 = 0.2024:  log likelihood = -106.62
## AIC=217.25   AICc=217.32   BIC=223.54
##
## Training set error measures:
##                       ME      RMSE       MAE       MPE     MAPE      MASE
## Training set 0.05010242 0.4472642 0.3494763 0.2816909 2.981887 0.7910138
##                     ACF1
## Training set -0.01846638
```

```
NovsArimaFit = auto.arima(Novs, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(NovsArimaFit)
```

```
## Series: Novs
## ARIMA(0,1,1) with drift
##
## Coefficients:
##           ma1   drift
##       -0.8608  0.0105
## s.e.   0.0373  0.0067
##
## sigma^2 = 0.3725:  log likelihood = -158.81
## AIC=323.62   AICc=323.76   BIC=333.06
##
## Training set error measures:
##                       ME      RMSE       MAE       MPE     MAPE      MASE
## Training set 0.001950608 0.6050494 0.4847957 -1.319531 9.423161 0.7428419
##                     ACF1
## Training set -0.01841711
```

```
DecsArimaFit = auto.arima(Decs, stepwise = FALSE, approximation = FALSE, allowdrift = TRUE)

summary(DecsArimaFit)
```

```
## Series: Decs
## ARIMA(3,1,2) with drift
##
## Coefficients:
##          ar1     ar2      ar3      ma1     ma2   drift
##       0.9183  0.0542  -0.2259  -1.8372  0.8716  0.0093
## s.e.  0.1021  0.1015   0.0811   0.0746  0.0732  0.0071
##
## sigma^2 = 0.4744:  log likelihood = -178.08
## AIC=370.16   AICc=370.84   BIC=392.19
##
## Training set error measures:
##                       ME      RMSE       MAE      MPE     MAPE      MASE
## Training set 0.005130545 0.6746876 0.5367095 3.581654 150.2769 0.7018703
##                     ACF1
## Training set -0.01895019
```

```r
# Load the grid package
library(grid)

# Create a basic plot with a custom grid layout
grid.newpage()
pushViewport(viewport(layout = grid.layout(3, 3)))
```

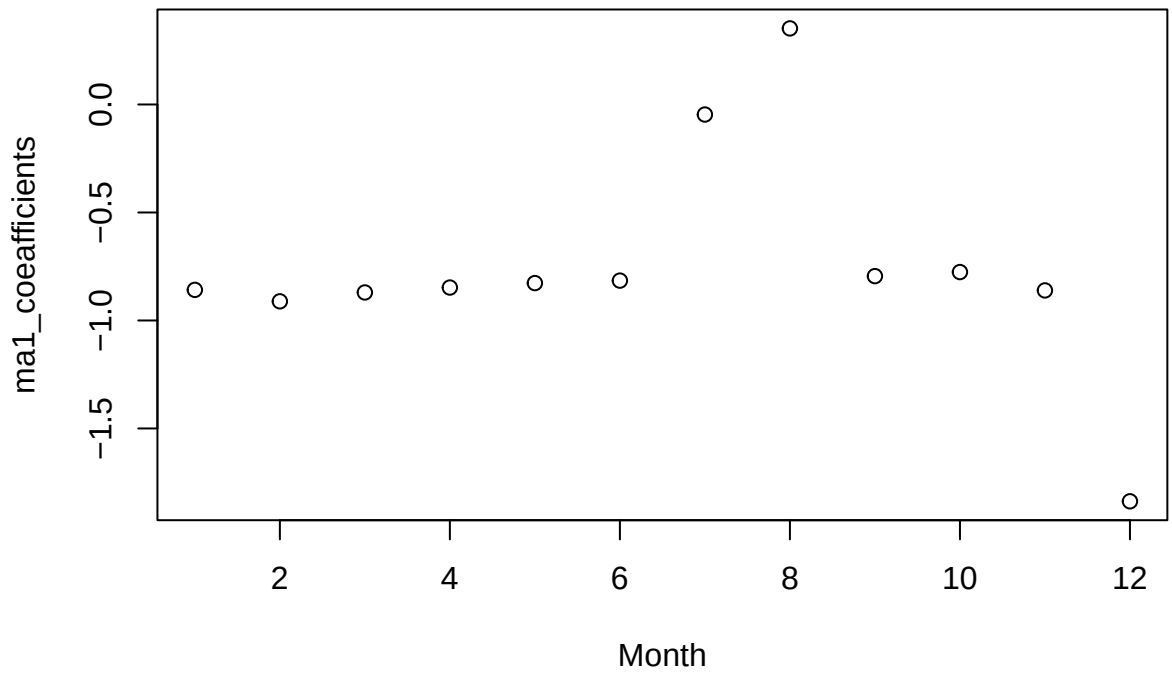
```r
# Define a function to place a plot in a specific grid cell
plot_in_grid <- function(row, col, plot_function) {
  vp <- viewport(layout.pos.row = row, layout.pos.col = col)
  pushViewport(vp)
  plot_function()
  popViewport()
}
```

plotting ma1 coefficient for each month:

```r
ma1_coeafficients = c(JansArimaFit$coef['ma1'], FebsArimaFit$coef['ma1'], MarsArimaFit$coef['ma1'],
                      AprsArimaFit$coef['ma1'], MaysArimaFit$coef['ma1'], JunsArimaFit$coef['ma1'],
                      JulsArimaFit$coef['ma1'], AugsArimaFit$coef['ma1'], SepsArimaFit$coef['ma1'],
                      OctsArimaFit$coef['ma1'], NovsArimaFit$coef['ma1'], DecsArimaFit$coef['ma1'])
c("Jan", "Feb", "Mar", "Apr", "May", "Jun", "Jul", "Aug", "Sep", "Oct", "Nov", "Dec")
```

```
##  [1] "Jan" "Feb" "Mar" "Apr" "May" "Jun" "Jul" "Aug" "Sep" "Oct" "Nov" "Dec"
```

```r
plot(c(1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12), ma1_coeafficients, xlab="Month")
```



Minmum window size:

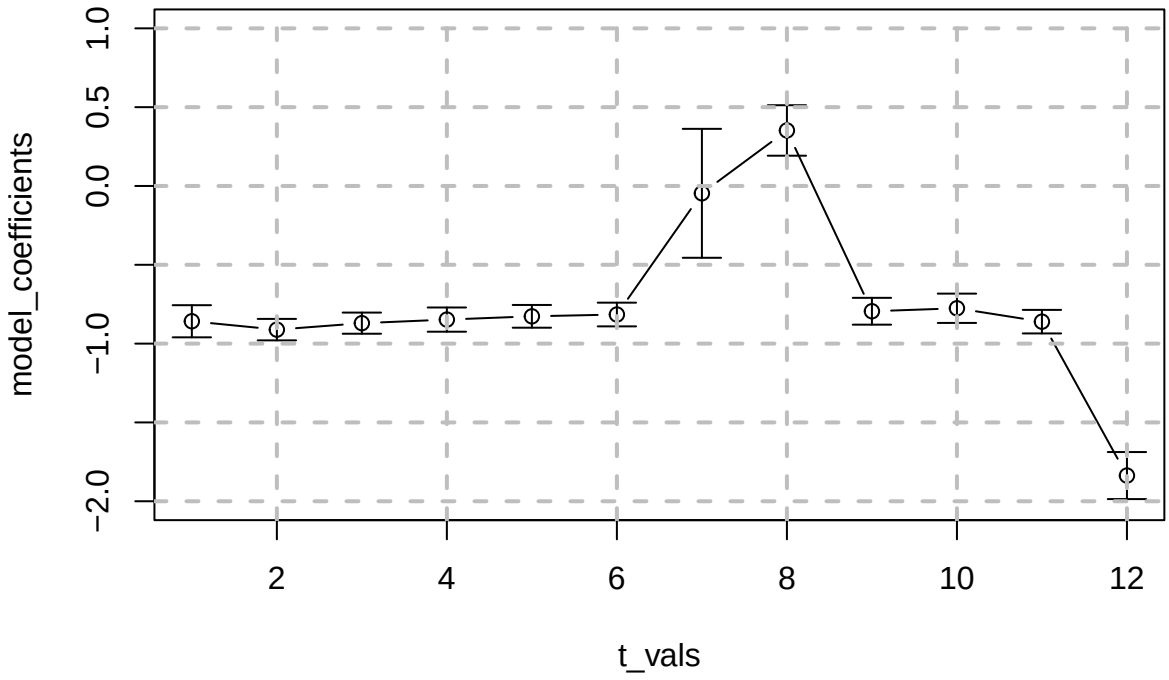
Inspired from Wacyl's work.

The smaller the AIC the better the model, however,

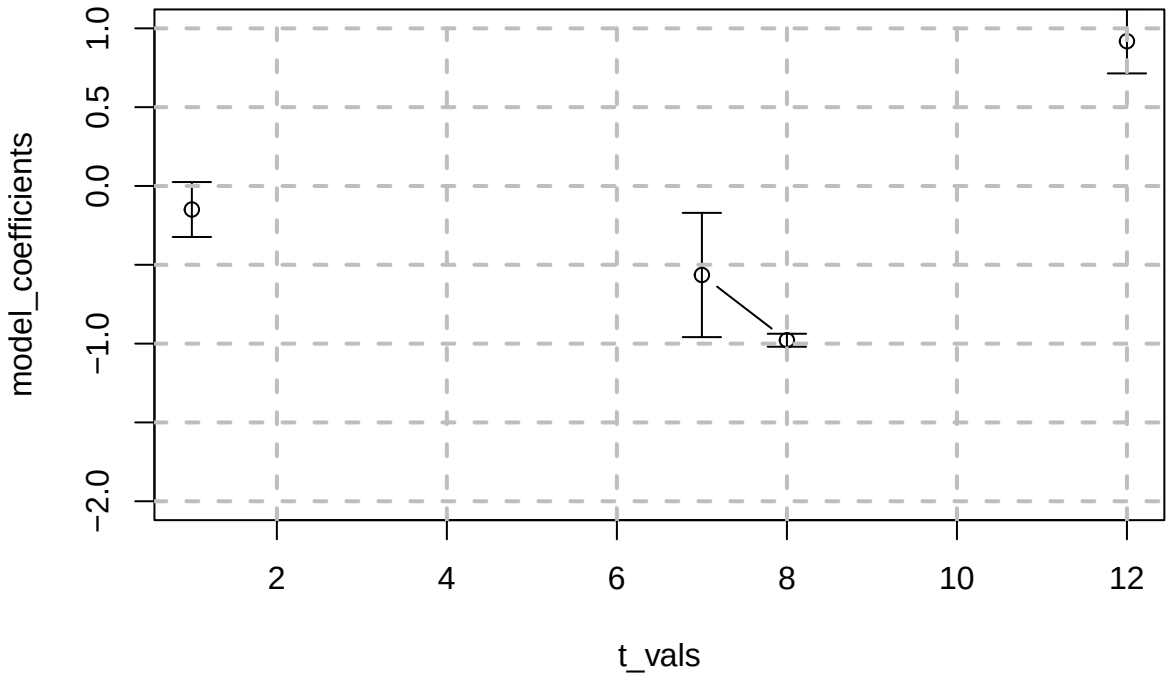
```r
months_models = cbind(c(JansArimaFit), c(FebsArimaFit), c(MarsArimaFit),
                  c(AprsArimaFit), c(MaysArimaFit), c(JunsArimaFit),
                  c(JulsArimaFit), c(AugsArimaFit), c(SepsArimaFit),
                  c(OctsArimaFit), c(NovsArimaFit), c(DecsArimaFit))
```

```
## Warning in cbind(c(JansArimaFit), c(FebsArimaFit), c(MarsArimaFit),
## c(AprsArimaFit), : number of rows of result is not a multiple of vector length
## (arg 10)
```

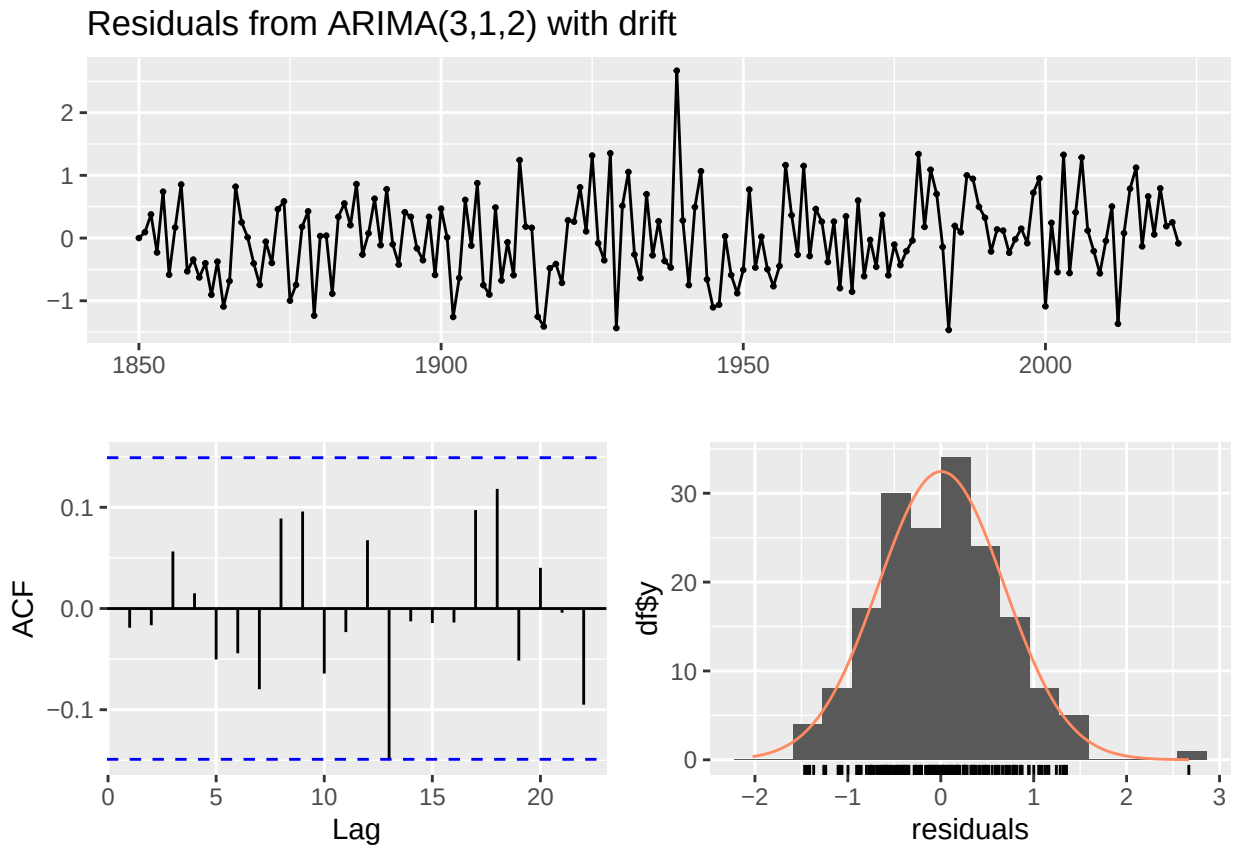
```r
plot_arima_coef <- function(models, c){

  model_coefficients <- c()
  errors <- c()


  for (model in 1:length(models[1, ])){
      model_coefficients <- cbind(model_coefficients, models[, model]$coef[c])
      std_error <- sqrt(diag(models[, model]$var.coef))[c]
      errors <- cbind(errors, std_error)
  }

  t_vals<-seq_along(models[1,])

  MyPlot = (plot(t_vals, model_coefficients, type='b', ylim = c(-2, 1)) +
    arrows(x0=t_vals, y0=model_coefficients-2*errors, x1 = t_vals, y1=model_coefficients+2*errors, code=
    grid(nx = NULL, ny = NULL,
     lty = 2,      # Grid line type
     col = "gray", # Grid line color
     lwd = 2)      # Grid line width
}

plot_arima_coef(months_models, "ma1")
```




```
plot_arima_coef(months_models, "ar1")
```




```
checkresiduals(DecsArimaFit)
```




```
##
##  Ljung-Box test
##
## data:  Residuals from ARIMA(3,1,2) with drift
## Q* = 6.6015, df = 5, p-value = 0.252
##
## Model df: 5.   Total lags used: 10
```