PSTAT174-Project

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```
library(tidyverse)
library(ggplot2)
library(ggfortify)
library(ggthemes)
library(zoo)
library(forecast)
library(Mcomp)
library(MASS)
library(fabletools)
library(reshape2)
```

```
EU_Max_Temperatures <- read.csv("Temperatures_In_Europe.csv")

names(EU_Max_Temperatures) <- c("date", "Berlin", "Paris", "Copenhagen", "Stockholm", "Rome")


head(EU_Max_Temperatures, 5)
```

```
##      date Berlin Paris Copenhagen Stockholm Rome
## 1 1900-01    8.4  12.7        6.2       5.0   NA
## 2 1900-02   17.4  16.9        6.2       4.5   NA
## 3 1900-03   15.0  16.9        7.6       5.5   NA
## 4 1900-04   24.1  25.8       19.2      14.0   NA
## 5 1900-05   29.4  28.9       23.4      21.0   NA
```

```
summary(EU_Max_Temperatures)
```

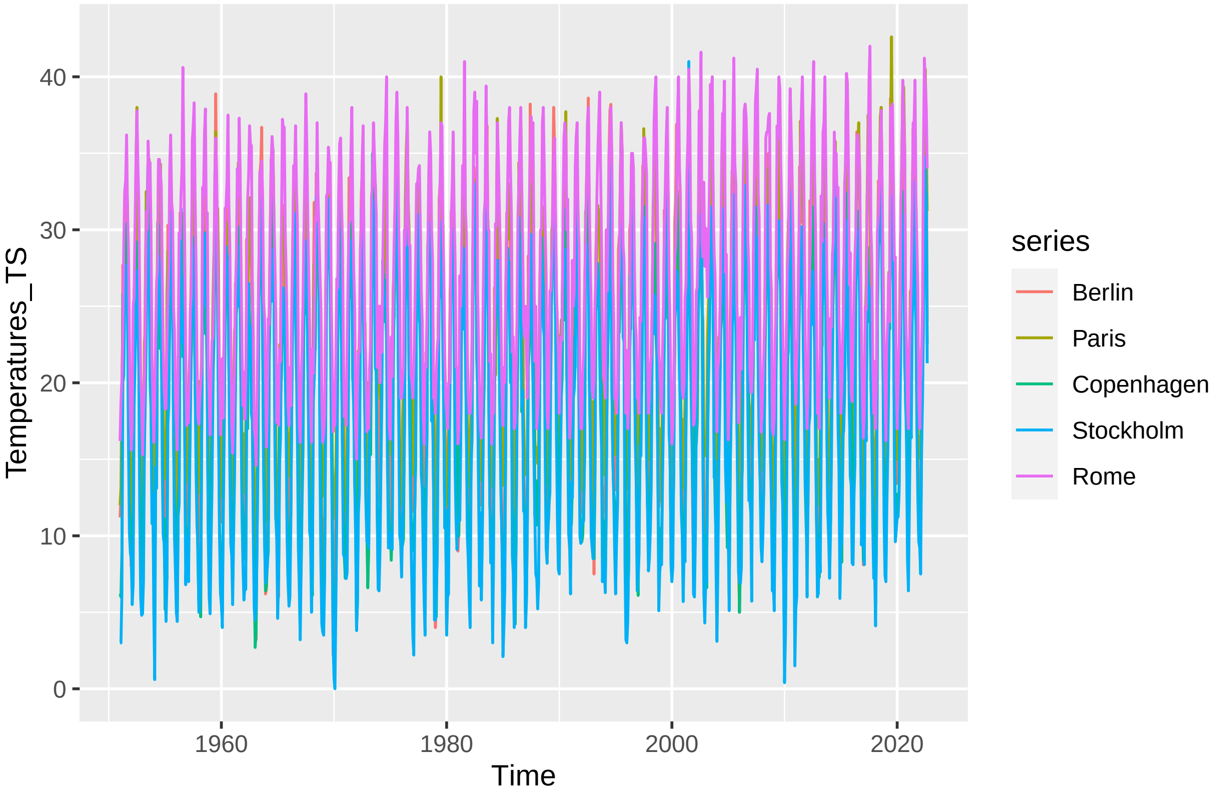
```
##      date               Berlin          Paris         Copenhagen
##  Length:1473        Min.   : 1.50   Min.   : 6.10   Min.   : 1.50
##  Class :character   1st Qu.:13.90   1st Qu.:16.00   1st Qu.:10.80
##  Mode  :character   Median :22.70   Median :23.72   Median :18.50
##                     Mean   :21.92   Mean   :23.29   Mean   :18.35
##                     3rd Qu.:29.90   3rd Qu.:29.80   3rd Qu.:25.90
##                      Max.   :38.90   Max.   :42.61   Max.   :39.10
##
##    Stockholm          Rome
##  Min.   : 0.00   Min.   :14.60
##  1st Qu.: 9.00   1st Qu.:21.00
##  Median :16.75   Median :27.00
##  Mean   :16.95   Mean   :27.23
##  3rd Qu.:25.00   3rd Qu.:33.50
##  Max.   :41.00   Max.   :42.00
##  NA's   :3       NA's   :576
```

However, there is some missing data within the column for Rome as seen above so we must remove them. Because the data set is rather large to begin with starting all the way from the year 1900, we can get rid of data from each other column until Rome finally has some. Looking at the data set, Rome begins to have some data when `date = 1944-06`, but is still patchy with this information until around `1951-01`. Therefore, all data from before this will be removed and only from 1951 and onward will be analyzed.

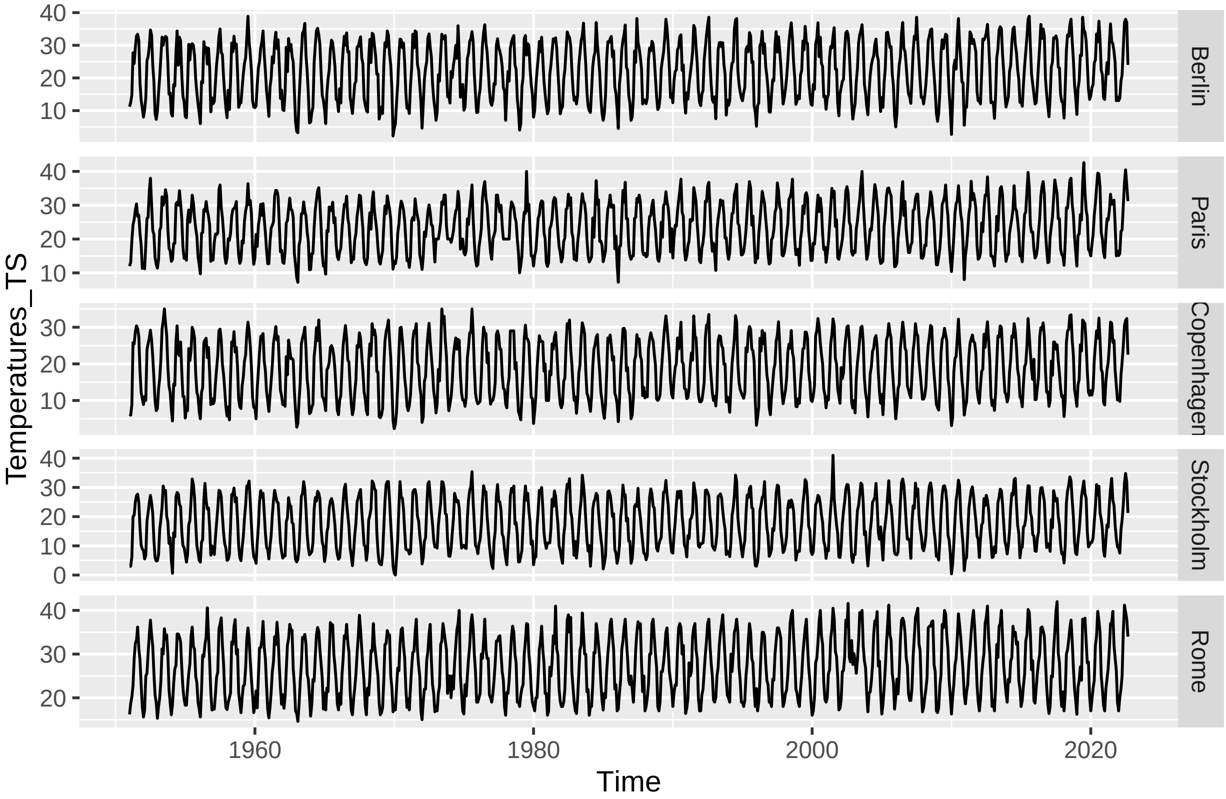
```
EU_Max_Temperatures <- EU_Max_Temperatures[EU_Max_Temperatures$date >= '1951-01',]
head(EU_Max_Temperatures, 5)
```

```
##        date Berlin Paris Copenhagen Stockholm Rome
## 613 1951-01   11.2  12.0      6.200       3.0 16.2
## 614 1951-02   12.5  13.1      6.000       3.0 18.7
## 615 1951-03   14.8  19.6      8.889       6.2 20.2
## 616 1951-04   27.7  24.2     25.800      20.0 22.8
## 617 1951-05   24.4  25.8     25.400      20.5 29.0
```

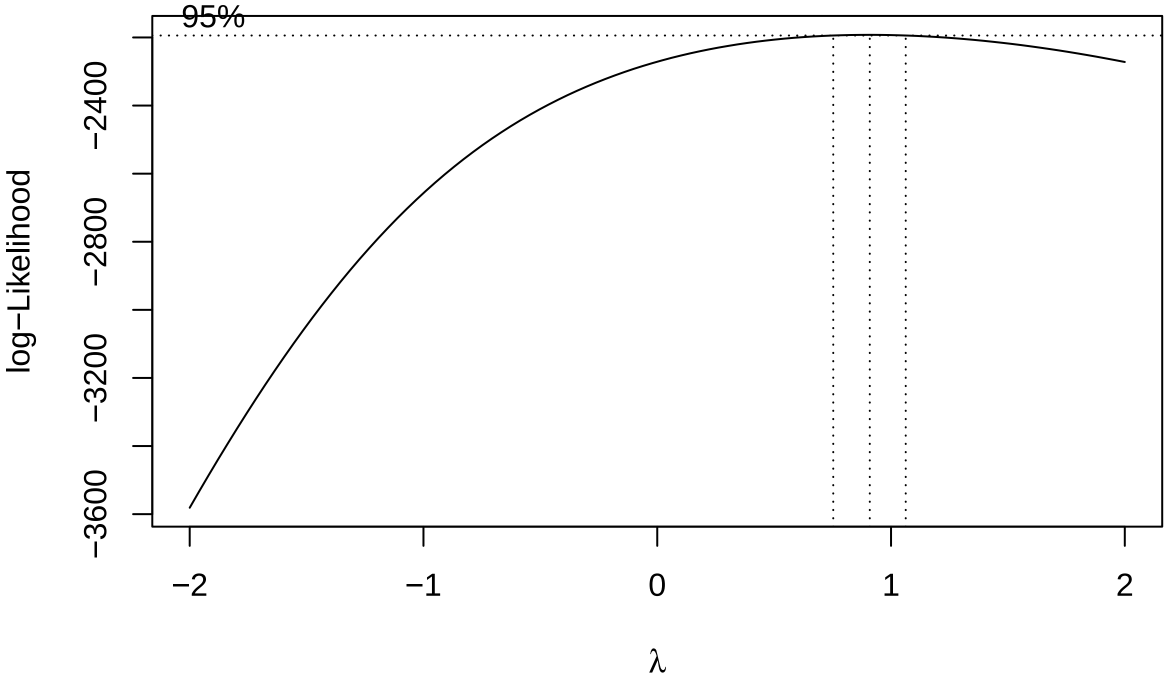
```
Temperatures_TS <- ts(EU_Max_Temperatures[,c(2:6)], start = c(1951), frequency = 12)


options(repr.plot.width =2, repr.plot.height =3)
autoplot(Temperatures_TS)
```



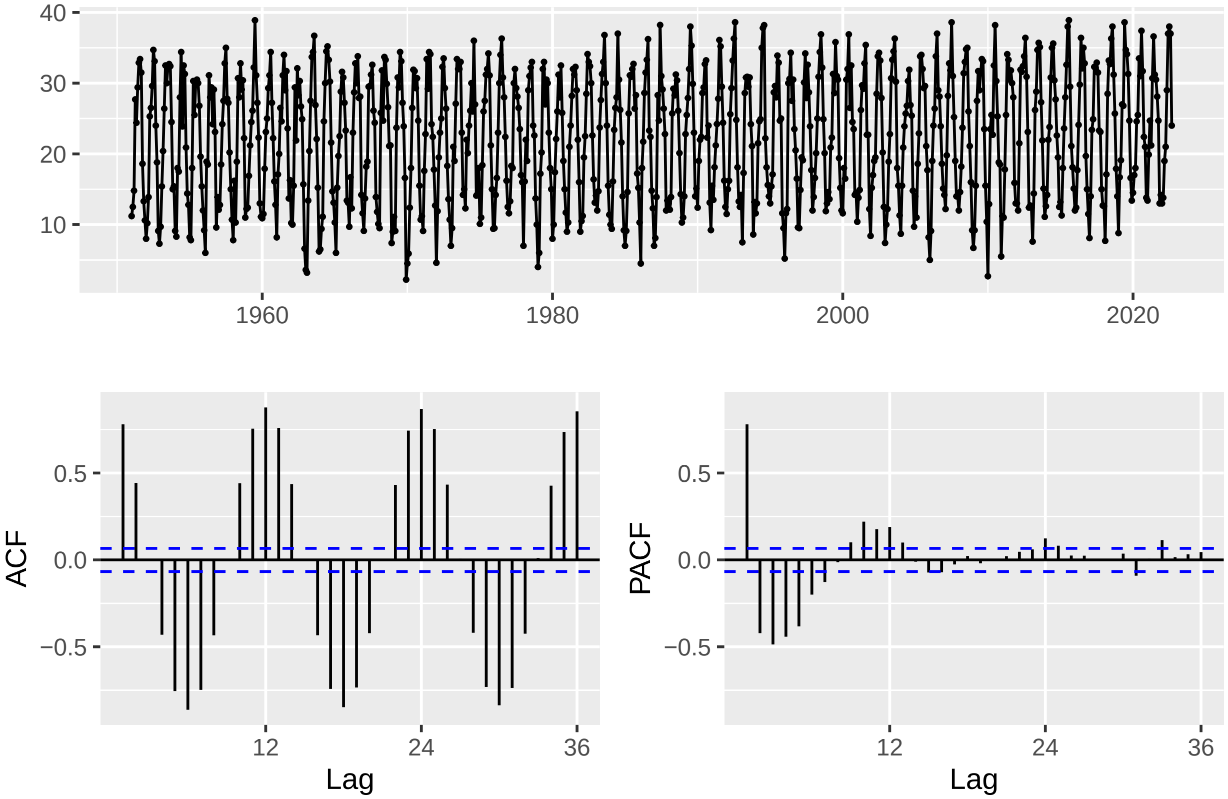
```
autoplot(Temperatures_TS, facets = TRUE)
```



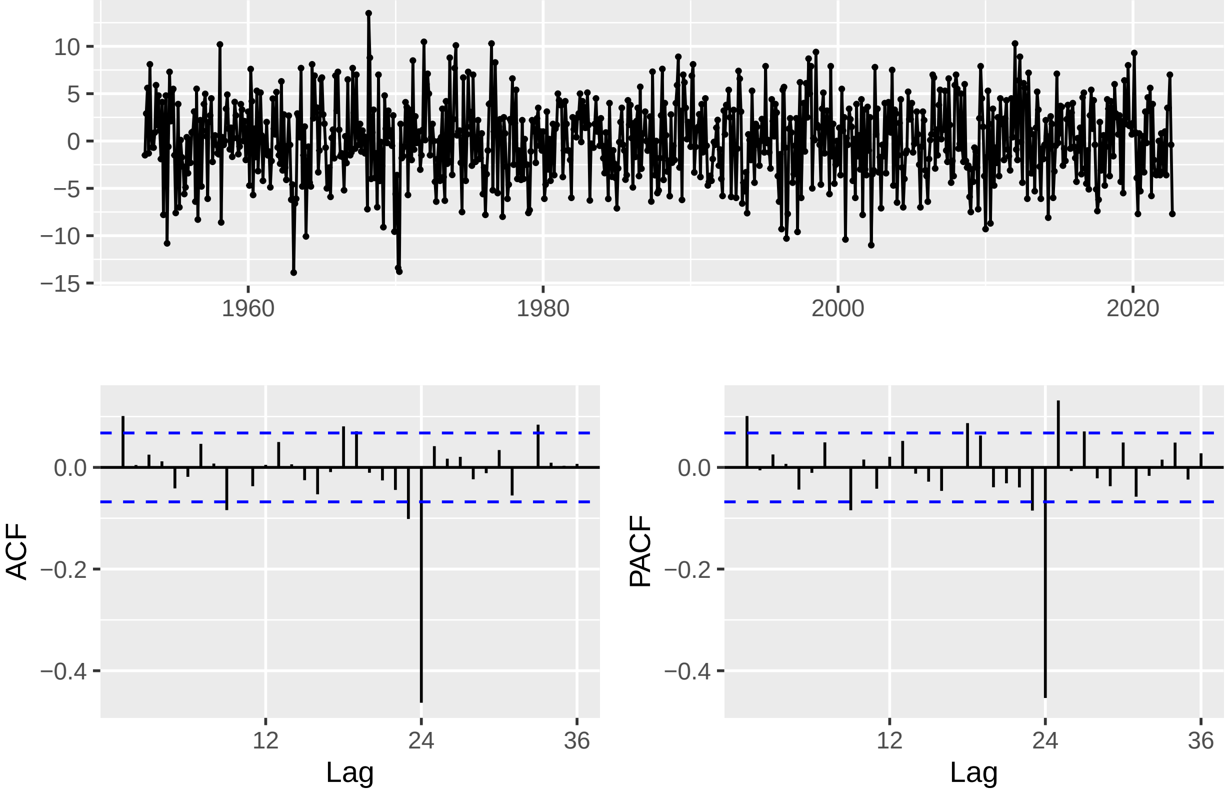
```
boxcox(lm(Temperatures_TS[,1] ~ 1))
```



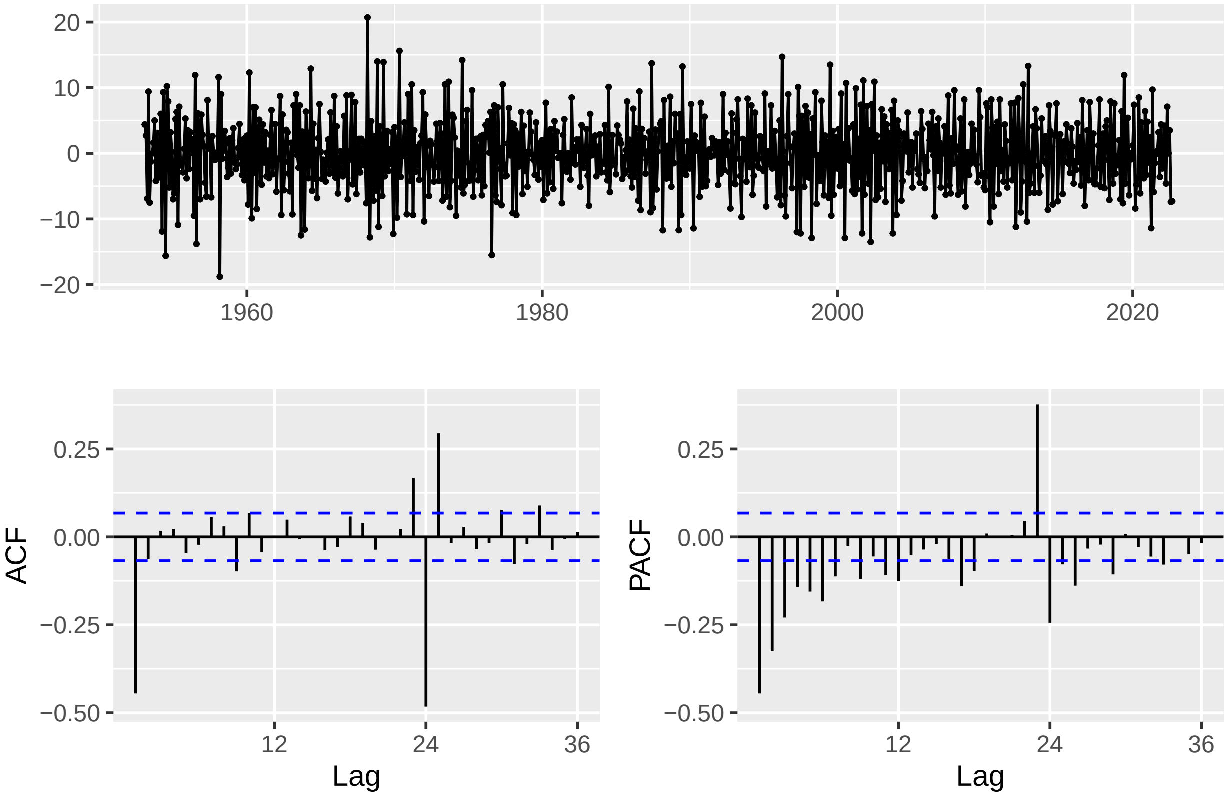
```
Temperatures_TS[,1] %>%

  ggtsdisplay()
```



```
Temperatures_TS[,1] %>%
  diff(lag = 24) %>%
  ggtsdisplay()
```

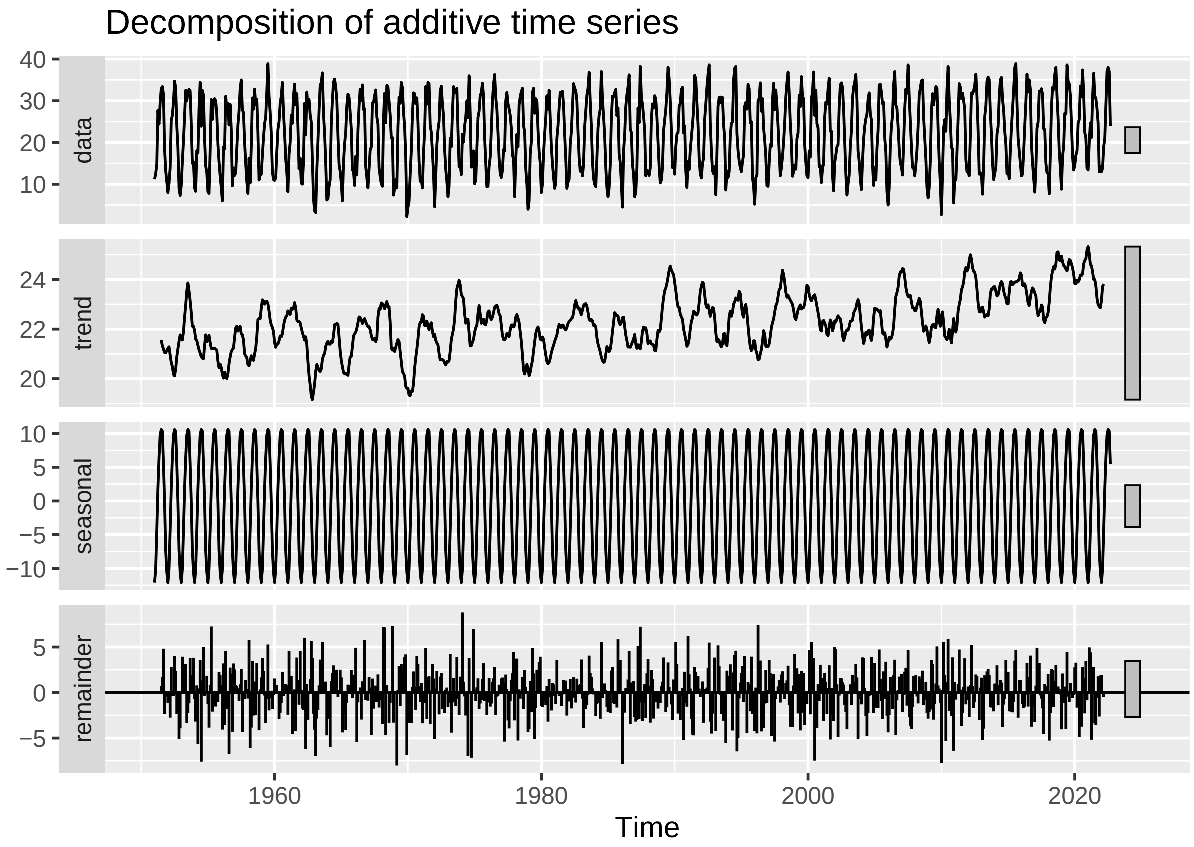


```
Temperatures_TS[,1] %>%
  diff(lag = 24) %>% diff() %>%
  ggtsdisplay()
```

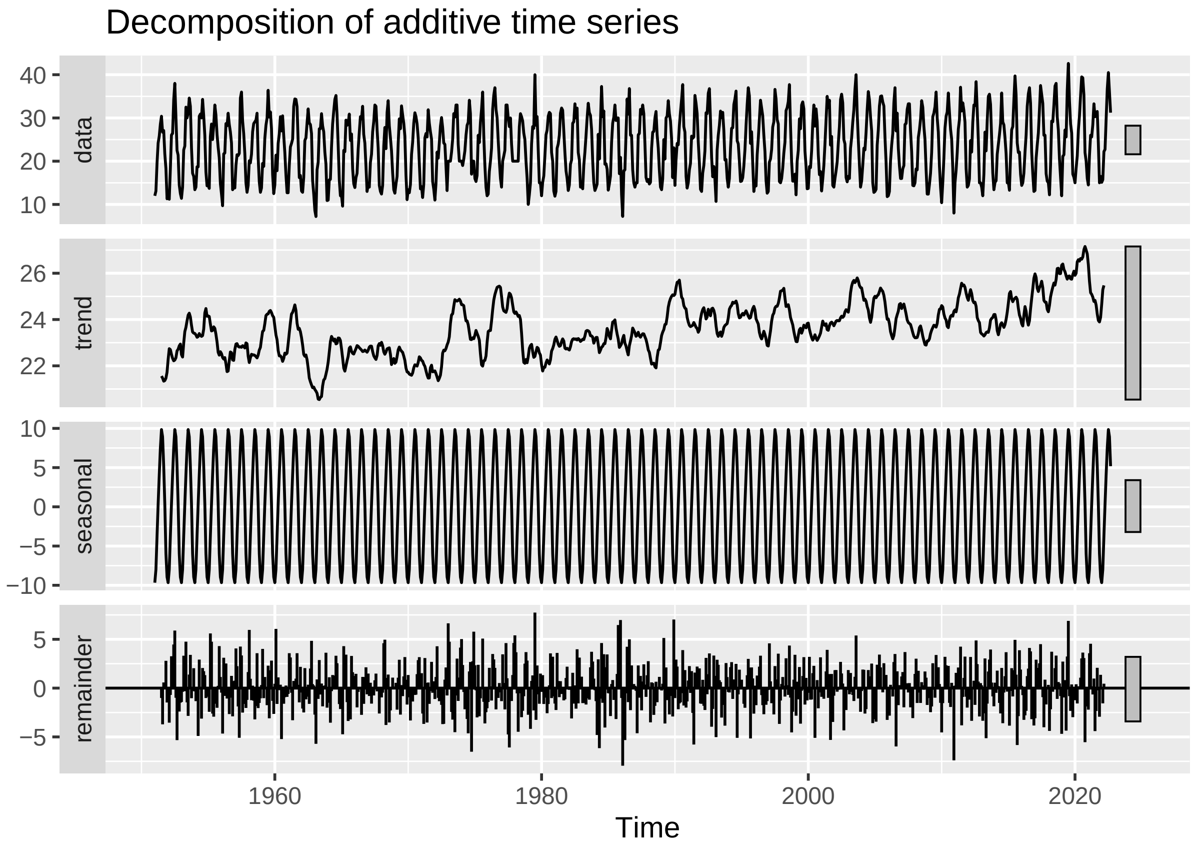


When rounding to the closest $lambda$ value, $lambda = 1$. Therefore, we do not need to make any BoxCox transformations to the data.

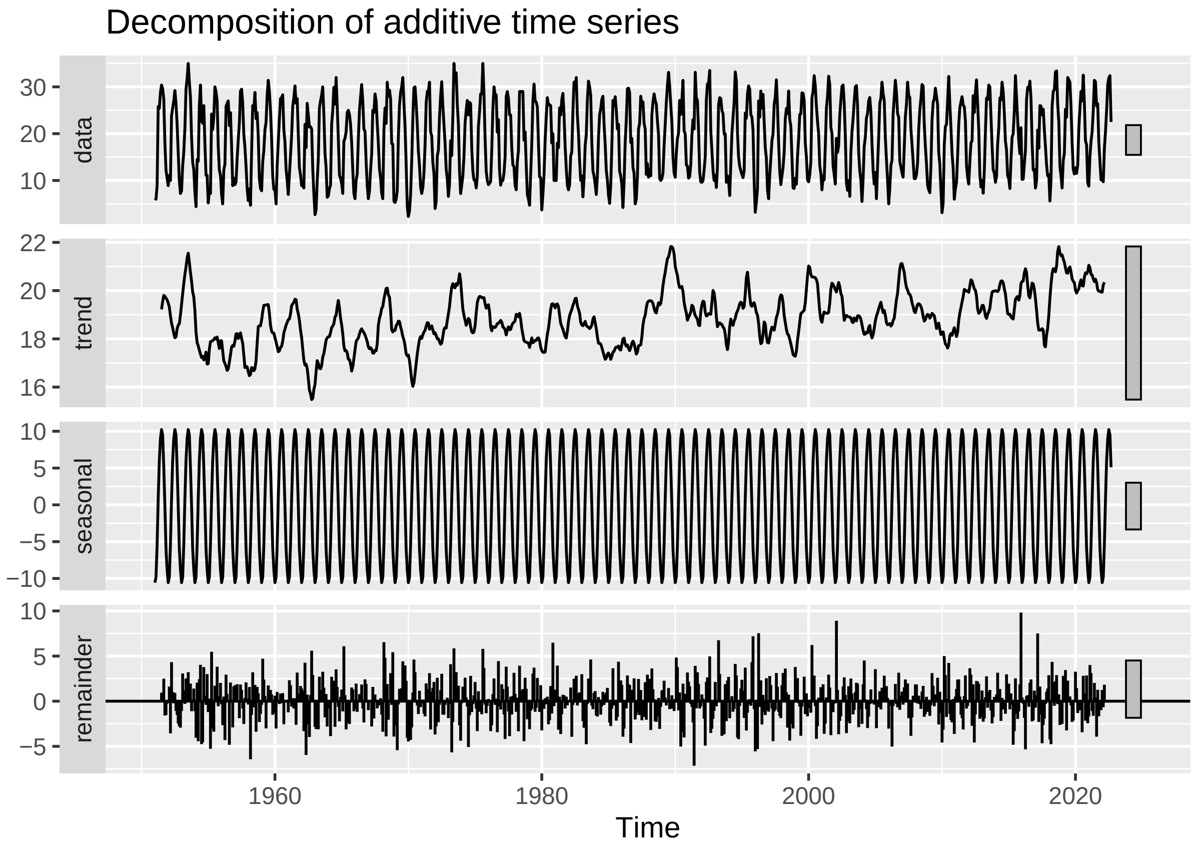
```
Decomp_Temperatures_TS_Berlin <- decompose(Temperatures_TS[,1])
Decomp_Temperatures_TS_Paris <- decompose(Temperatures_TS[,2])
Decomp_Temperatures_TS_Copenhagen <- decompose(Temperatures_TS[,3])
Decomp_Temperatures_TS_Stockholm <- decompose(Temperatures_TS[,4])
Decomp_Temperatures_TS_Rome <- decompose(Temperatures_TS[,5])


autoplot(Decomp_Temperatures_TS_Berlin)
```



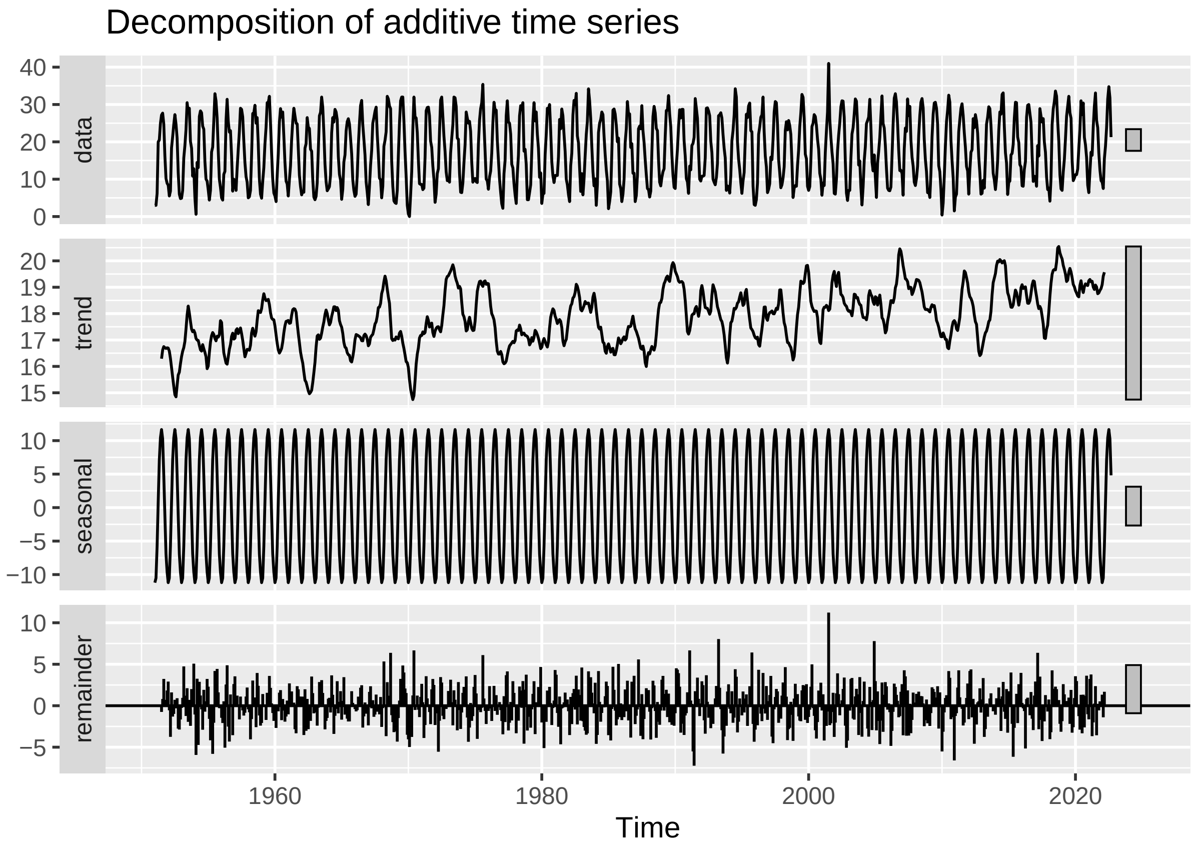
```
autoplot(Decomp_Temperatures_TS_Paris)
```



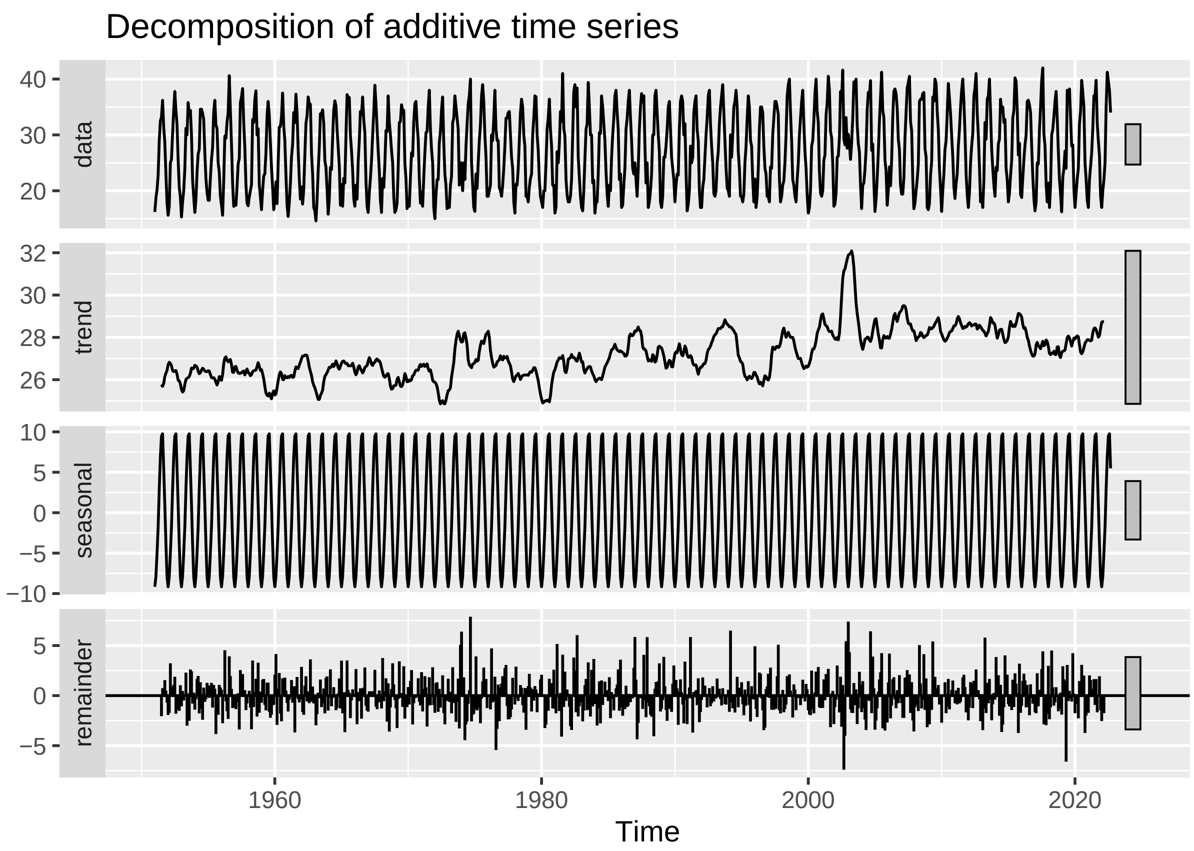
```
autoplot(Decomp_Temperatures_TS_Copenhagen)
```



```
autoplot(Decomp_Temperatures_TS_Stockholm)
```



```
autoplot(Decomp_Temperatures_TS_Rome)
```



```
Box.test(Temperatures_TS[,1], type = c("Box-Pierce"), fitdf = 0)
```

```
##
##  Box-Pierce test
##
## data:  Temperatures_TS[, 1]
## X-squared = 523.75, df = 1, p-value < 2.2e-16
```

```
Box.test(Temperatures_TS[,1], type = c("Ljung-Box"), fitdf = 0)
```

```
##
##  Box-Ljung test
##
## data:  Temperatures_TS[, 1]
## X-squared = 525.58, df = 1, p-value < 2.2e-16
```

```
fit.auto <- auto.arima(Temperatures_TS[,1], seasonal = TRUE, trace = TRUE)
```

```
##
##  Fitting models using approximations to speed things up...
##
##  ARIMA(2,0,2)(1,1,1)[12] with drift         : 4300.446
##  ARIMA(0,0,0)(0,1,0)[12] with drift         : 4781.884
##  ARIMA(1,0,0)(1,1,0)[12] with drift         : 4526.764
##  ARIMA(0,0,1)(0,1,1)[12] with drift         : Inf
##  ARIMA(0,0,0)(0,1,0)[12]                    : 4779.913
##  ARIMA(2,0,2)(0,1,1)[12] with drift         : Inf
##  ARIMA(2,0,2)(1,1,0)[12] with drift         : 4525.586
##  ARIMA(2,0,2)(2,1,1)[12] with drift         : Inf
##  ARIMA(2,0,2)(1,1,2)[12] with drift         : Inf
##  ARIMA(2,0,2)(0,1,0)[12] with drift         : Inf
##  ARIMA(2,0,2)(0,1,2)[12] with drift         : Inf
##  ARIMA(2,0,2)(2,1,0)[12] with drift         : 4435.207
##  ARIMA(2,0,2)(2,1,2)[12] with drift         : Inf
##  ARIMA(1,0,2)(1,1,1)[12] with drift         : Inf
##  ARIMA(2,0,1)(1,1,1)[12] with drift         : 4298.5
##  ARIMA(2,0,1)(0,1,1)[12] with drift         : Inf
##  ARIMA(2,0,1)(1,1,0)[12] with drift         : 4525.525
##  ARIMA(2,0,1)(2,1,1)[12] with drift         : Inf
##  ARIMA(2,0,1)(1,1,2)[12] with drift         : Inf
##  ARIMA(2,0,1)(0,1,0)[12] with drift         : 4778.582
##  ARIMA(2,0,1)(0,1,2)[12] with drift         : Inf
##  ARIMA(2,0,1)(2,1,0)[12] with drift         : 4432.844
##  ARIMA(2,0,1)(2,1,2)[12] with drift         : Inf
##  ARIMA(1,0,1)(1,1,1)[12] with drift         : 4289.263
##  ARIMA(1,0,1)(0,1,1)[12] with drift         : Inf
##  ARIMA(1,0,1)(1,1,0)[12] with drift         : 4528.602
##  ARIMA(1,0,1)(2,1,1)[12] with drift         : Inf
##  ARIMA(1,0,1)(1,1,2)[12] with drift         : Inf
##  ARIMA(1,0,1)(0,1,0)[12] with drift         : 4776.299
##  ARIMA(1,0,1)(0,1,2)[12] with drift         : Inf
##  ARIMA(1,0,1)(2,1,0)[12] with drift         : 4433.311
##  ARIMA(1,0,1)(2,1,2)[12] with drift         : Inf
##  ARIMA(0,0,1)(1,1,1)[12] with drift         : Inf
##  ARIMA(1,0,0)(1,1,1)[12] with drift         : 4287.821
##  ARIMA(1,0,0)(0,1,1)[12] with drift         : Inf
##  ARIMA(1,0,0)(2,1,1)[12] with drift         : 4283.094
##  ARIMA(1,0,0)(2,1,0)[12] with drift         : 4431.334
##  ARIMA(1,0,0)(2,1,2)[12] with drift         : Inf
##  ARIMA(1,0,0)(1,1,2)[12] with drift         : Inf
##  ARIMA(0,0,0)(2,1,1)[12] with drift         : 4294.406
##  ARIMA(2,0,0)(2,1,1)[12] with drift         : 4277.927
##  ARIMA(2,0,0)(1,1,1)[12] with drift         : 4298.618
##  ARIMA(2,0,0)(2,1,0)[12] with drift         : 4432.557
##  ARIMA(2,0,0)(2,1,2)[12] with drift         : Inf
##  ARIMA(2,0,0)(1,1,0)[12] with drift         : 4528.485
##  ARIMA(2,0,0)(1,1,2)[12] with drift         : Inf
##  ARIMA(3,0,0)(2,1,1)[12] with drift         : 4277.281
##  ARIMA(3,0,0)(1,1,1)[12] with drift         : 4298.679
##  ARIMA(3,0,0)(2,1,0)[12] with drift         : 4435.082
##  ARIMA(3,0,0)(2,1,2)[12] with drift         : Inf
##  ARIMA(3,0,0)(1,1,0)[12] with drift         : 4526.9
##  ARIMA(3,0,0)(1,1,2)[12] with drift         : Inf
##  ARIMA(4,0,0)(2,1,1)[12] with drift         : 4283.697
##  ARIMA(3,0,1)(2,1,1)[12] with drift         : Inf
##  ARIMA(4,0,1)(2,1,1)[12] with drift         : 4279.952
##  ARIMA(3,0,0)(2,1,1)[12]                    : 4277.496
##
##  Now re-fitting the best model(s) without approximations...
##
##  ARIMA(3,0,0)(2,1,1)[12] with drift         : Inf
##  ARIMA(3,0,0)(2,1,1)[12]                    : Inf
##  ARIMA(2,0,0)(2,1,1)[12] with drift         : Inf
##  ARIMA(4,0,1)(2,1,1)[12] with drift         : Inf
##  ARIMA(1,0,0)(2,1,1)[12] with drift         : Inf
##  ARIMA(4,0,0)(2,1,1)[12] with drift         : Inf
##  ARIMA(1,0,0)(1,1,1)[12] with drift         : Inf
##  ARIMA(1,0,1)(1,1,1)[12] with drift         : Inf
##  ARIMA(0,0,0)(2,1,1)[12] with drift         : Inf
##  ARIMA(2,0,1)(1,1,1)[12] with drift         : Inf
##  ARIMA(2,0,0)(1,1,1)[12] with drift         : Inf
##  ARIMA(3,0,0)(1,1,1)[12] with drift         : Inf
##  ARIMA(2,0,2)(1,1,1)[12] with drift         : Inf
##  ARIMA(1,0,0)(2,1,0)[12] with drift         : 4469.039
##
##  Best model: ARIMA(1,0,0)(2,1,0)[12] with drift
```

```r
#Get mean and variance of time series


mean_Berlin <- sum(EU_Max_Temperatures[2])/nrow(EU_Max_Temperatures[2])
mean_Paris <- sum(EU_Max_Temperatures[3])/nrow(EU_Max_Temperatures[3])
mean_Copenhagen <- sum(EU_Max_Temperatures[4])/nrow(EU_Max_Temperatures[4])
mean_Stockholm <- sum(EU_Max_Temperatures[5])/nrow(EU_Max_Temperatures[5])
mean_Rome <- sum(EU_Max_Temperatures[6])/nrow(EU_Max_Temperatures[6])


var_Berlin <- var(EU_Max_Temperatures[2])
var_Paris <- var(mean_Paris)
var_Copenhagen <- var(mean_Copenhagen)
var_Stockholm <- var(mean_Stockholm)
var_Rome <- var(mean_Rome)
```