R Notebook

Chargement des Librairies Nécessaires

```r
install.packages('readxl', repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/mk/hc7kkglj5fncc3271_yfcf6r0000gn/T//RtmpQEkpkD/downloaded_packages
```

```r
library(readxl)

install.packages('tidyverse', repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/mk/hc7kkglj5fncc3271_yfcf6r0000gn/T//RtmpQEkpkD/downloaded_packages
```

```r
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v dplyr     1.1.4     v readr     2.1.5
## v forcats   1.0.0     v stringr   1.5.1
## v ggplot2   3.5.1     v tibble    3.2.1
## v lubridate 1.9.3     v tidyr     1.3.1
## v purrr     1.0.2
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become error
```

```r
install.packages("fpp2", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/mk/hc7kkglj5fncc3271_yfcf6r0000gn/T//RtmpQEkpkD/downloaded_packages
```

```r
library(fpp2)
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
## -- Attaching packages ---------------------------------------------- fpp2 2.5 --
## v forecast  8.23.0     v expsmooth 2.3
## v fma       2.5
```

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

##
```

```r
install.packages("forecast", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/mk/hc7kkglj5fncc3271_yfcf6r0000gn/T//RtmpQEkpkD/downloaded_packages
```

```r
library(forecast)

install.packages("ggplot2", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/mk/hc7kkglj5fncc3271_yfcf6r0000gn/T//RtmpQEkpkD/downloaded_packages
```

```r
library(ggplot2)

install.packages("openxlsx", repos = "http://cran.us.r-project.org")
```

```
##
## The downloaded binary packages are in
##  /var/folders/mk/hc7kkglj5fncc3271_yfcf6r0000gn/T//RtmpQEkpkD/downloaded_packages
```

```r
library(openxlsx)
```

Importation des Données

```r
data <- read_excel('/Users/annabellenarsama/Desktop/SeriesTemporelles/electrain.xlsx')
print(data)
```

```
## # A tibble: 4,987 x 3
##    Timestamp          `Power (kW)` `Temp (C°)`
##    <chr>                     <dbl>       <dbl>
##  1 40179.052083333336         165.        10.6
##  2 1/1/2010 1:30              152.        10.6
##  3 1/1/2010 1:45              147.        10.6
##  4 1/1/2010 2:00              154.        10.6
##  5 1/1/2010 2:15              154.        10.6
##  6 1/1/2010 2:30              159         10.6
##  7 1/1/2010 2:45              158.        10.6
##  8 1/1/2010 3:00              163.        10.6
##  9 1/1/2010 3:15              152.        10
## 10 1/1/2010 3:30              149.        10
## # i 4,977 more rows
```

Pour des raisons de symétrie, nous enlevons les 92 premières lignes qui correspondent au premier jour du mois, mais auxquelles il manque les 4 premières valeurs.

```r
newdata <- data[-(1:91), ]
print(newdata)
```

```
## # A tibble: 4,896 x 3
##    Timestamp     `Power (kW)` `Temp (C°)`
##    <chr>                <dbl>       <dbl>
##  1 1/2/2010 0:00         163.        13.3
##  2 1/2/2010 0:15         154.        10.6
##  3 1/2/2010 0:30         152.        10.6
##  4 1/2/2010 0:45         159.        10.6
##  5 1/2/2010 1:00         164.        10.6
##  6 1/2/2010 1:15         159.        10
##  7 1/2/2010 1:30         152.        10
##  8 1/2/2010 1:45         155.        10
##  9 1/2/2010 2:00         156.        10
## 10 1/2/2010 2:15         152.        10
## # i 4,886 more rows
```

Transformation des Données en Série Temporelle

```r
newdata["jour"] <- weekdays(as.POSIXct(newdata$Timestamp, format="%m/%d/%Y %H:%M"))
newdata["heure"] <- format(strptime(newdata$Timestamp, format="%m/%d/%Y %H:%M"))
print(newdata)
```

```
## # A tibble: 4,896 x 5
##    Timestamp     `Power (kW)` `Temp (C°)` jour     heure
##    <chr>                <dbl>       <dbl> <chr>    <chr>
##  1 1/2/2010 0:00         163.        13.3 Saturday 2010-01-02 00:00:00
##  2 1/2/2010 0:15         154.        10.6 Saturday 2010-01-02 00:15:00
##  3 1/2/2010 0:30         152.        10.6 Saturday 2010-01-02 00:30:00
##  4 1/2/2010 0:45         159.        10.6 Saturday 2010-01-02 00:45:00
##  5 1/2/2010 1:00         164.        10.6 Saturday 2010-01-02 01:00:00
##  6 1/2/2010 1:15         159.        10   Saturday 2010-01-02 01:15:00
##  7 1/2/2010 1:30         152.        10   Saturday 2010-01-02 01:30:00
##  8 1/2/2010 1:45         155.        10   Saturday 2010-01-02 01:45:00
##  9 1/2/2010 2:00         156.        10   Saturday 2010-01-02 02:00:00
## 10 1/2/2010 2:15         152.        10   Saturday 2010-01-02 02:15:00
## # i 4,886 more rows
```

```r
elec <- ts(newdata$`Power (kW)`, start=c(1,6), end=c(51,96), freq=96)
print(elec)
```

```
## Time Series:
## Start = c(1, 6)
## End = c(51, 96)
## Frequency = 96
```

```
##   [1] 163.1 154.4 152.2 158.7 163.8 158.7 152.3 155.2 155.9 152.1 154.1 155.9
##  [13] 156.8 153.9 152.2 165.6 168.8 160.5 160.6 161.1 160.7 157.0 161.7 158.4
##  [25] 165.8 166.4 168.0 159.5 164.2 170.3 178.8 181.5 182.4 270.9 269.4 273.1
##  [37] 268.3 277.7 269.8 268.0 258.3 260.7 257.2 256.3 255.0 270.9 269.6 307.6
##  [49] 283.5 266.1 295.9 278.5 269.5 297.5 294.4 300.7 287.5 288.4 288.4 283.9
##  [61] 310.4 285.3 288.9 277.1 280.3 271.8 301.8 282.2 285.0 326.2 311.7 313.4
##  [73] 305.0 300.7 303.2 299.8 307.7 315.8 304.1 305.6 290.9 289.4 285.2 276.6
##  [85] 282.0 291.6 286.9 290.1 285.1 285.7 286.6 281.9 281.3 190.3 194.8 163.7
##  [97] 159.3 158.4 152.9 159.6 161.6 159.9 149.8 148.7 153.2 150.6 151.6 160.6
## [109] 165.7 154.9 149.0 163.5 161.2 158.6 154.9 162.0 162.7 160.3 162.3 168.3
## [121] 165.3 166.8 166.7 172.6 171.1 175.5 185.4 188.8 186.6 267.0 267.3 262.6
## [133] 258.2 262.0 259.4 256.6 258.2 262.8 264.7 262.9 263.8 270.7 264.2 269.3
## [145] 265.9 265.7 261.7 270.9 280.0 281.0 278.9 276.5 276.0 273.1 270.2 276.3
## [157] 265.0 266.2 267.3 275.4 273.0 273.0 272.5 266.3 284.0 315.0 313.9 314.4
## [169] 312.9 310.0 310.1 310.1 317.6 312.9 308.0 306.9 305.5 297.2 293.6 300.0
## [181] 292.8 288.1 285.8 286.9 283.8 193.6 191.7 158.9 169.1 161.4 166.9 165.0
## [193] 164.1 168.5 155.4 166.7 161.3 163.1 152.5 147.0 154.6 161.0 158.9 159.3
## [205] 165.4 160.9 151.5 157.2 166.1 161.9 161.4 167.9 162.2 166.7 163.5 164.0
## [217] 170.2 166.3 177.2 174.5 168.1 189.4 188.9 176.8 181.7 268.0 261.1 258.5
## [229] 261.7 264.2 258.3 266.4 267.4 265.7 265.2 264.2 266.3 262.8 262.4 265.5
## [241] 270.7 261.6 272.9 275.8 271.0 276.3 274.0 276.1 278.1 274.5 276.6 271.6
## [253] 271.9 272.8 271.0 271.9 277.7 267.8 266.1 269.5 279.1 312.1 314.1 309.7
## [265] 310.2 302.1 301.4 304.5 305.6 312.9 306.0 308.3 305.1 296.7 299.9 298.2
## [277] 300.2 300.4 283.8 277.6 286.2 288.7 293.2 288.2 286.5 191.9 198.2 170.3
## [289] 162.5 160.2 146.1 159.8 165.4 154.7 156.3 154.1 160.8 157.0 155.9 161.3
## [301] 161.0 153.8 143.3 154.8 163.6 161.8 160.7 160.6 157.2 154.1 162.3 161.4
## [313] 156.6 161.7 164.4 178.8 184.2 178.9 184.6 174.9 180.3 272.6 263.5 257.3
## [325] 262.8 269.4 266.7 262.9 265.7 263.7 269.7 265.9 274.2 273.6 268.6 268.4
## [337] 265.5 269.2 271.1 273.5 277.8 270.9 273.0 269.8 274.5 267.4 273.3 264.5
## [349] 265.5 267.1 272.7 268.4 271.0 268.6 266.1 270.9 279.3 312.1 308.1 305.1
## [361] 302.3 305.0 305.9 298.4 304.0 309.3 302.2 302.2 311.6 308.7 305.6 303.5
## [373] 303.0 300.4 299.3 299.8 287.9 288.7 291.7 290.3 288.6 193.7 198.5 167.3
## [385] 162.3 160.2 148.8 154.0 164.0 168.6 153.6 148.7 159.4 151.4 155.0 154.7
## [397] 158.6 156.2 149.8 155.3 159.4 160.1 155.2 161.5 159.8 157.4 161.1 162.0
## [409] 160.0 163.4 166.2 170.5 175.0 184.7 198.3 181.2 192.8 274.0 269.9 258.8
## [421] 261.8 268.8 264.5 268.5 266.6 261.6 269.2 256.9 260.2 269.4 269.5 267.9
## [433] 266.6 272.3 271.9 265.1 257.4 260.7 261.0 265.4 274.3 273.9 265.8 269.7
## [445] 264.4 271.3 267.3 258.4 265.7 272.1 268.7 266.7 272.3 308.3 310.2 308.3
## [457] 310.1 309.3 303.7 303.0 304.4 313.9 307.8 310.6 301.8 308.0 304.7 305.8
## [469] 309.5 305.5 303.7 302.5 293.2 284.6 286.5 283.0 283.2 187.2 194.6 156.2
## [481] 161.1 155.5 155.0 153.2 159.6 164.4 151.6 143.0 147.9 155.2 157.7 152.9
## [493] 158.5 146.4 145.2 156.3 154.7 159.3 159.2 160.4 157.6 153.8 152.7 158.6
## [505] 155.5 153.8 163.4 168.4 168.0 184.1 193.5 172.9 182.9 275.5 265.7 259.1
## [517] 262.5 265.5 258.0 261.1 268.9 259.0 256.4 264.4 268.2 275.9 270.9 268.6
## [529] 264.5 263.5 270.2 269.6 274.1 274.3 270.8 274.5 274.9 273.7 276.2 266.0
## [541] 270.8 270.8 265.7 270.9 266.7 271.3 268.3 267.3 276.5 311.1 310.5 313.6
## [553] 308.9 308.5 308.1 304.5 302.4 309.7 306.4 303.1 301.2 305.8 300.5 298.1
## [565] 304.0 302.7 299.0 301.2 302.5 287.9 286.4 284.6 287.1 194.4 202.0 167.0
## [577] 164.6 161.4 156.2 162.8 161.8 166.0 153.5 157.0 162.6 159.1 167.3 161.6
## [589] 162.3 155.0 152.0 161.7 160.3 155.9 160.3 161.3 159.1 164.8 167.0 170.9
## [601] 170.4 173.8 178.8 172.0 168.1 177.1 180.6 185.5 172.6 258.1 267.0 265.9
## [613] 262.4 269.3 264.2 263.1 265.0 259.6 262.9 270.5 267.2 268.9 266.7 268.5
## [625] 271.7 271.5 274.8 272.3 269.7 271.3 270.6 274.4 275.5 269.6 266.4 264.2
## [637] 266.6 270.1 270.1 274.5 275.4 271.3 271.8 271.1 280.2 319.5 317.1 317.7
```

```
##  [649] 311.3 306.1 307.3 308.4 308.9 313.0 307.2 305.2 304.9 306.3 301.1 298.9
##  [661] 299.9 296.6 295.4 303.8 299.3 282.4 283.3 279.9 285.1 191.7 190.5 157.8
##  [673] 157.6 159.3 144.0 157.1 157.5 162.7 149.7 146.9 160.3 153.2 156.7 154.7
##  [685] 154.7 151.9 144.3 151.7 156.7 150.6 154.9 150.0 153.6 151.5 158.5 161.5
##  [697] 153.4 158.8 154.9 160.9 164.0 184.9 188.1 173.3 172.4 268.0 263.1 260.0
##  [709] 260.0 260.8 255.7 264.3 267.3 261.0 260.9 261.7 265.1 267.2 261.0 269.9
##  [721] 263.8 268.2 269.3 269.3 266.6 263.9 264.2 270.4 270.2 262.8 263.3 270.3
##  [733] 272.2 270.4 267.1 275.2 270.5 273.3 266.6 261.7 266.5 310.3 306.8 307.1
##  [745] 316.8 310.0 306.0 307.1 308.4 309.3 307.2 306.4 308.5 304.3 301.2 300.0
##  [757] 303.5 304.6 292.1 283.4 284.1 281.0 284.8 287.8 293.5 196.9 193.8 168.3
##  [769] 164.3 160.6 152.8 152.6 160.8 154.4 155.4 151.9 149.4 145.5 146.3 148.8
##  [781] 147.8 148.4 153.5 149.3 147.0 156.0 157.7 159.7 153.0 153.2 155.5 161.0
##  [793] 160.6 158.5 167.0 161.2 162.6 175.0 193.2 180.5 180.2 261.1 256.5 256.6
##  [805] 254.6 258.2 257.3 261.4 254.6 252.1 260.3 264.1 265.1 271.1 267.5 261.3
##  [817] 268.3 260.2 267.4 270.7 265.2 269.5 268.9 269.4 270.8 270.0 273.4 271.3
##  [829] 268.0 276.4 273.4 270.2 273.3 266.8 270.1 272.0 272.0 310.5 314.4 314.0
##  [841] 312.9 300.6 307.2 303.8 307.5 313.8 306.3 298.1 302.4 304.1 306.9 307.0
##  [853] 306.6 293.1 294.3 291.3 287.6 199.3 199.4 163.0 165.6 161.7 166.4 166.8
##  [865] 169.9 170.3 160.4 163.9 173.1 169.6 162.9 154.9 159.2 150.8 168.0 163.9
##  [877] 168.6 152.0 158.0 168.4 169.7 164.1 163.1 167.4 168.6 166.4 173.7 172.1
##  [889] 175.2 171.5 183.2 199.1 190.8 190.1 185.9 185.2 184.1 269.8 264.6 262.6
##  [901] 263.7 263.9 258.2 259.2 266.0 264.5 270.7 268.3 269.4 264.3 267.7 267.0
##  [913] 273.4 276.2 272.9 272.3 270.2 269.1 273.1 271.2 267.1 271.1 266.2 272.9
##  [925] 269.3 265.0 261.7 267.1 264.8 267.3 263.5 264.1 263.5 307.0 311.0 308.4
##  [937] 311.6 304.2 304.3 295.3 293.3 302.4 304.1 302.5 301.3 298.8 303.2 300.3
##  [949] 298.3 296.6 292.7 296.8 291.8 290.1 288.7 287.3 285.6 189.2 199.0 163.9
##  [961] 160.0 164.6 152.9 165.8 160.7 154.1 162.7 161.1 159.1 160.4 161.0 161.9
##  [973] 163.4 160.2 156.1 160.8 160.3 164.3 164.7 161.5 164.1 165.5 171.3 176.7
##  [985] 168.5 170.0 178.3 180.0 179.2 187.0 200.6 185.5 190.1 282.3 275.1 266.5
##  [997] 273.4 283.3 273.8 278.7 270.5 268.6 265.9 262.5 271.6 270.2 295.7 285.4
## [1009] 288.1 283.3 300.4 279.2 304.7 298.5 293.8 286.1 275.7 283.7 287.7 294.4
## [1021] 288.1 282.5 293.9 295.8 302.5 296.7 285.1 288.2 277.1 327.0 329.9 331.2
## [1033] 341.5 322.0 317.4 319.8 327.5 336.6 330.3 326.5 323.6 318.7 323.5 320.6
## [1045] 319.5 315.7 310.6 310.0 324.4 306.2 297.3 307.4 307.7 222.9 223.1 182.4
## [1057] 183.5 184.0 178.1 184.9 180.4 177.0 162.4 155.0 157.7 164.7 164.5 172.1
## [1069] 178.4 167.2 162.8 168.7 165.8 167.8 166.2 172.9 171.7 168.5 170.6 172.3
## [1081] 173.9 175.0 181.2 171.3 172.7 197.8 189.3 179.4 189.8 268.2 274.1 263.1
## [1093] 257.2 272.5 265.4 274.4 287.0 283.8 263.1 258.0 261.6 267.7 268.6 268.6
## [1105] 272.6 269.4 270.9 275.5 264.7 273.8 268.2 275.3 276.0 277.0 276.1 274.8
## [1117] 276.9 275.4 268.6 269.2 271.2 270.5 274.2 288.7 287.9 321.8 333.7 318.3
## [1129] 312.5 309.1 308.3 319.9 323.2 313.9 313.0 308.2 302.2 304.0 302.6 297.2
## [1141] 303.0 294.0 311.9 317.7 303.3 287.3 282.4 282.9 284.4 196.8 191.5 159.1
## [1153] 159.0 163.5 157.2 165.9 163.8 166.5 155.4 152.6 158.3 155.2 159.7 158.2
## [1165] 163.8 162.6 155.5 165.8 159.4 160.7 159.5 160.3 155.9 168.6 159.6 159.7
## [1177] 155.6 164.3 171.5 173.0 174.0 178.5 184.7 173.7 179.0 255.7 255.3 253.0
## [1189] 256.8 262.7 253.8 262.7 258.5 261.9 259.0 255.9 256.6 271.0 266.5 261.5
## [1201] 271.4 263.4 259.2 265.2 262.0 268.2 268.5 266.9 261.7 268.6 264.8 267.2
## [1213] 264.8 268.3 264.1 264.0 267.7 260.7 268.4 256.9 261.8 297.9 304.2 302.9
## [1225] 301.3 298.4 300.4 293.2 295.1 305.7 306.2 304.4 299.0 300.2 302.5 305.0
## [1237] 305.5 303.3 293.0 289.1 293.1 287.2 286.9 285.4 289.5 200.8 198.5 167.7
## [1249] 165.7 157.9 152.9 156.8 160.5 169.3 163.5 149.6 158.5 158.7 166.2 165.0
## [1261] 167.2 161.8 157.1 164.5 167.2 163.3 162.4 162.1 158.5 164.3 162.5 167.4
## [1273] 165.3 173.0 172.9 179.2 197.1 191.4 186.7 170.9 176.8 264.5 261.2 253.1
## [1285] 254.1 261.3 255.2 259.2 259.3 253.1 259.7 262.1 253.7 264.7 260.2 259.6
```

```
## [1297] 261.0 269.8 272.6 267.2 263.7 263.7 266.0 262.4 261.7 263.1 260.5 263.1
## [1309] 263.2 267.7 268.2 271.2 270.8 268.7 260.0 259.1 262.1 297.6 302.3 302.4
## [1321] 296.6 301.1 301.9 303.9 301.6 308.3 304.4 299.7 295.6 301.9 300.0 303.4
## [1333] 301.7 290.4 291.1 287.3 291.7 288.7 283.5 277.3 277.9 192.6 193.3 161.5
## [1345] 155.5 153.2 134.1 155.0 150.8 162.5 155.9 156.3 160.6 152.8 159.3 159.1
## [1357] 152.7 148.8 147.2 149.7 155.6 153.9 149.4 152.6 150.9 151.8 152.3 155.5
## [1369] 150.5 159.7 160.8 159.7 154.0 161.6 170.3 171.0 173.3 258.3 253.0 250.5
## [1381] 249.2 251.2 249.8 253.4 250.1 254.0 253.8 259.9 259.0 264.3 255.0 258.0
## [1393] 258.5 263.3 265.3 261.2 264.4 268.5 269.2 271.8 265.4 268.6 266.6 263.5
## [1405] 263.6 266.4 270.5 266.2 262.6 260.9 262.5 263.5 255.9 290.1 307.4 307.2
## [1417] 304.2 298.8 290.9 295.1 299.4 307.1 306.0 298.4 296.7 297.9 298.2 299.9
## [1429] 298.6 294.1 296.5 287.4 288.1 285.6 284.2 283.3 291.4 195.5 190.7 152.6
## [1441] 152.0 148.9 142.7 152.6 153.6 156.6 149.9 150.4 150.3 146.0 148.1 156.5
## [1453] 155.3 159.2 156.8 154.4 163.4 154.9 149.6 151.7 160.0 156.0 158.8 153.4
## [1465] 159.0 156.5 160.6 164.3 164.1 180.9 177.8 168.4 168.3 258.3 252.1 250.3
## [1477] 250.0 260.7 256.1 258.7 256.0 254.8 251.3 256.0 260.3 266.4 259.0 261.2
## [1489] 260.7 264.1 267.9 268.7 268.3 267.0 267.4 264.8 268.5 265.4 264.3 262.9
## [1501] 261.0 267.9 267.9 264.5 266.6 266.8 263.3 265.6 262.1 287.1 308.2 312.1
## [1513] 309.5 305.6 304.7 298.3 302.2 306.9 300.0 297.3 302.4 301.9 295.3 291.7
## [1525] 282.7 287.1 284.7 280.5 281.0 195.1 193.1 159.7 163.4 160.4 168.1 164.6
## [1537] 160.8 158.9 156.3 163.5 167.1 165.3 165.9 155.5 153.9 154.7 151.2 158.6
## [1549] 171.1 163.3 183.4 176.9 178.3 177.2 168.7 163.8 169.0 165.7 180.4 176.4
## [1561] 171.7 173.1 186.3 198.0 186.8 195.0 213.5 192.7 204.2 269.6 268.9 273.2
## [1573] 261.4 269.5 269.1 266.8 267.5 252.6 260.2 274.4 264.5 274.6 274.8 278.9
## [1585] 285.8 298.3 274.2 269.9 271.4 272.6 270.0 269.5 266.8 266.7 269.1 265.2
## [1597] 270.5 266.3 266.4 267.8 264.0 267.4 266.6 268.4 261.9 287.8 308.9 307.5
## [1609] 308.4 299.2 292.7 294.6 298.3 303.7 295.1 302.9 300.9 303.7 302.6 299.6
## [1621] 297.9 293.9 293.1 290.5 288.5 277.2 278.4 285.1 288.0 193.2 194.3 166.4
## [1633] 158.4 163.7 153.7 155.7 154.4 160.4 147.1 160.9 168.6 160.6 160.1 155.7
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## [3949] 157.3 154.4 154.6 155.5 157.6 156.6 155.4 158.2 161.0 162.1 170.1 166.2
## [3961] 169.1 169.0 202.9 190.7 187.5 186.1 167.4 176.5 173.5 258.9 256.4 257.0
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## [4069] 241.4 251.8 247.1 248.1 242.9 243.1 248.7 247.4 256.0 252.3 254.8 249.0
## [4081] 250.5 257.1 261.7 256.6 257.5 257.5 255.6 260.9 254.4 254.8 262.4 267.0
## [4093] 282.3 318.4 267.9 265.7 323.9 282.3 272.2 306.7 254.0 258.3 257.6 287.8
## [4105] 303.0 305.3 304.9 308.4 302.6 308.1 304.8 301.9 302.6 304.7 305.7 312.7
## [4117] 325.9 300.0 304.8 302.5 292.2 290.6 283.7 281.0 283.0 196.0 196.3 162.9
## [4129] 156.9 160.4 155.0 153.9 150.9 149.2 145.9 141.6 143.5 142.8 148.5 146.4
## [4141] 149.8 150.1 155.2 157.7 157.6 158.2 157.8 153.0 149.9 152.6 152.6 154.4
## [4153] 154.3 156.8 169.7 160.6 169.2 171.2 155.6 155.6 164.3 242.9 250.0 244.7
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## [4177] 246.0 246.7 249.9 251.0 245.3 247.6 252.7 250.6 249.5 255.9 253.2 257.6
## [4189] 260.0 267.0 311.0 262.2 254.9 250.0 311.1 277.9 252.2 281.1 279.4 279.0
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## [4225] 154.8 154.0 150.4 152.2 159.6 160.0 156.6 154.7 159.9 159.1 163.0 157.0
## [4237] 159.6 157.3 155.1 159.3 160.2 162.0 157.9 162.7 159.7 162.7 163.4 166.6
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## [4261] 248.4 249.0 246.2 249.1 248.2 251.3 247.1 246.4 241.4 245.8 246.1 247.4
## [4273] 246.0 250.1 250.8 251.6 253.3 257.9 252.0 261.7 249.3 255.8 256.8 284.5
## [4285] 304.2 247.2 286.5 292.5 252.0 254.1 252.4 282.4 279.6 259.1 289.3 269.8
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## [4381] 295.8 295.4 247.0 263.3 269.8 271.9 297.2 258.0 269.3 272.3 249.1 304.0
## [4393] 316.0 299.2 334.1 308.1 305.9 330.9 292.4 317.3 316.0 296.0 325.9 308.7
## [4405] 290.6 304.9 299.2 297.9 292.7 270.6 265.4 270.9 276.2 192.7 187.1 149.5
## [4417] 150.9 151.9 144.1 150.7 154.9 156.0 155.3 157.8 160.2 162.3 152.5 170.4
## [4429] 164.5 159.4 150.2 153.6 157.5 155.1 150.8 151.5 153.2 152.9 153.1 154.9
## [4441] 160.6 156.0 162.4 182.1 178.5 181.5 175.1 171.0 176.3 252.8 249.6 242.1
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## [4477] 288.6 309.1 293.2 287.0 264.1 282.7 283.4 279.1 277.8 260.6 257.0 295.2
## [4489] 328.9 296.2 332.4 323.8 311.4 315.0 327.8 326.2 316.1 299.9 336.4 324.7
## [4501] 302.3 321.9 305.4 299.8 294.3 283.7 285.5 288.2 295.2 205.4 200.0 145.3
## [4513]   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0   0.0 120.6
## [4525] 123.4 129.8 130.0 138.8 156.4 153.4 150.9 136.7 149.9 155.4 151.8 149.4
```
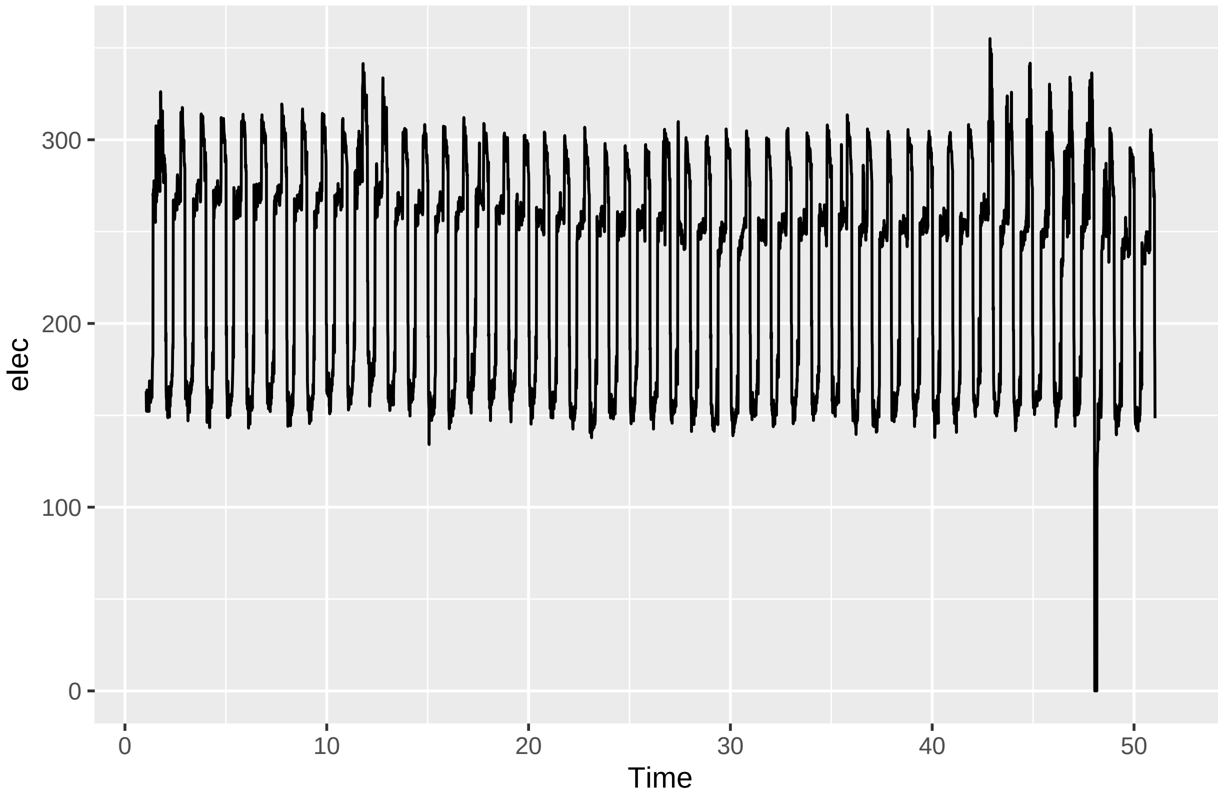

```
## [4537] 159.2 153.0 160.2 167.2 174.6 165.8 148.8 153.6 161.3 239.8 239.7 240.5
## [4549] 245.1 247.7 246.1 242.5 240.7 246.2 249.8 253.0 273.7 269.0 254.8 283.6
## [4561] 252.0 270.5 280.0 255.3 251.8 278.1 287.2 247.2 277.6 273.4 249.1 263.1
## [4573] 258.9 260.3 262.7 256.8 264.3 262.4 255.4 233.3 236.2 255.5 248.8 278.2
## [4585] 306.3 291.4 302.3 298.0 299.9 303.9 303.2 303.1 299.5 299.4 287.0 286.3
## [4597] 288.6 277.0 272.7 274.9 269.4 274.1 270.7 268.6 269.2 197.1 188.9 155.1
## [4609] 148.2 147.8 148.7 154.9 155.9 150.5 140.5 139.4 145.0 150.1 154.7 149.6
## [4621] 146.9 149.1 147.2 153.5 148.5 144.1 151.0 146.7 149.9 151.8 156.1 152.7
## [4633] 158.5 165.8 178.2 166.5 170.3 169.4 154.9 154.9 167.0 241.2 238.9 240.2
## [4645] 238.4 242.2 245.9 238.2 239.7 240.3 242.4 235.3 236.1 242.7 244.6 247.0
## [4657] 242.9 240.0 252.0 257.8 249.9 245.3 246.7 251.8 241.7 245.9 242.5 246.2
## [4669] 245.0 242.7 241.4 243.7 236.2 241.6 246.2 241.9 240.7 245.5 237.5 251.3
## [4681] 295.7 293.7 291.2 290.2 293.1 294.6 289.3 288.2 283.5 292.4 282.7 283.6
## [4693] 289.6 285.9 284.6 290.7 285.5 277.3 275.6 274.0 279.3 198.1 191.0 157.7
## [4705] 151.9 147.0 145.1 152.6 154.2 154.1 143.9 146.0 142.6 148.6 154.4 149.6
## [4717] 148.7 146.7 141.5 147.1 150.3 150.1 148.2 148.8 147.8 146.8 151.1 150.1
## [4729] 152.4 161.7 184.1 173.6 169.7 164.2 164.5 168.0 166.3 244.0 241.1 234.6
## [4741] 239.0 240.0 234.2 235.4 238.3 232.5 237.1 235.4 233.8 232.7 234.1 232.3
## [4753] 242.9 243.2 240.1 247.6 246.4 244.1 250.0 242.8 239.8 244.3 243.9 245.2
## [4765] 249.9 244.4 247.2 242.4 241.5 240.0 240.4 238.4 241.8 246.1 239.7 252.8
## [4777] 299.2 302.9 305.5 292.6 294.5 303.1 293.4 291.3 292.6 288.9 291.9 292.9
## [4789] 287.9 287.4 282.6 284.5 276.2 268.9 272.5 271.2 269.8 189.6 177.9 148.4
## [4801]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4813]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4825]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4837]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4849]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4861]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4873]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4885]    NA    NA    NA    NA    NA    NA    NA
```

Visualisation de la Série Temporelle

```r
autoplot(elec)
```



On remarque un pic à 0 dans les données. Ce sont des valeurs à remplacer pour permettre la suite des analyses.

Gestion des valeurs à 0

On remplace à vue d'oeil les valeurs nulles. En effet, on peut voir que ces valeurs sont sur un pic qui tourne autour de 150. On fixe donc ces valeurs à 150.

```
newdata$`Power (kW)`[newdata$`Power (kW)` == 0] <- 150

elec <- ts(newdata$`Power (kW)`, start=c(1,1), end=c(51,96), freq=96)
print(elec)
```

```
## Time Series:
## Start = c(1, 1)
## End = c(51, 96)
## Frequency = 96
##     [1] 163.1 154.4 152.2 158.7 163.8 158.7 152.3 155.2 155.9 152.1 154.1 155.9
##    [13] 156.8 153.9 152.2 165.6 168.8 160.5 160.6 161.1 160.7 157.0 161.7 158.4
##    [25] 165.8 166.4 168.0 159.5 164.2 170.3 178.8 181.5 182.4 270.9 269.4 273.1
##    [37] 268.3 277.7 269.8 268.0 258.3 260.7 257.2 256.3 255.0 270.9 269.6 307.6
##    [49] 283.5 266.1 295.9 278.5 269.5 297.5 294.4 300.7 287.5 288.4 288.4 283.9
##    [61] 310.4 285.3 288.9 277.1 280.3 271.8 301.8 282.2 285.0 326.2 311.7 313.4
##    [73] 305.0 300.7 303.2 299.8 307.7 315.8 304.1 305.6 290.9 289.4 285.2 276.6
##    [85] 282.0 291.6 286.9 290.1 285.1 285.7 286.6 281.9 281.3 190.3 194.8 163.7
##    [97] 159.3 158.4 152.9 159.6 161.6 159.9 149.8 148.7 153.2 150.6 151.6 160.6
##   [109] 165.7 154.9 149.0 163.5 161.2 158.6 154.9 162.0 162.7 160.3 162.3 168.3
```

```
##  [121] 165.3 166.8 166.7 172.6 171.1 175.5 185.4 188.8 186.6 267.0 267.3 262.6
##  [133] 258.2 262.0 259.4 256.6 258.2 262.8 264.7 262.9 263.8 270.7 264.2 269.3
##  [145] 265.9 265.7 261.7 270.9 280.0 281.0 278.9 276.5 276.0 273.1 270.2 276.3
##  [157] 265.0 266.2 267.3 275.4 273.0 273.0 272.5 266.3 284.0 315.0 313.9 314.4
##  [169] 312.9 310.0 310.1 310.1 317.6 312.9 308.0 306.9 305.5 297.2 293.6 300.0
##  [181] 292.8 288.1 285.8 286.9 283.8 193.6 191.7 158.9 169.1 161.4 166.9 165.0
##  [193] 164.1 168.5 155.4 166.7 161.3 163.1 152.5 147.0 154.6 161.0 158.9 159.3
##  [205] 165.4 160.9 151.5 157.2 166.1 161.9 161.4 167.9 162.2 166.7 163.5 164.0
##  [217] 170.2 166.3 177.2 174.5 168.1 189.4 188.9 176.8 181.7 268.0 261.1 258.5
##  [229] 261.7 264.2 258.3 266.4 267.4 265.7 265.2 264.2 266.3 262.8 262.4 265.5
##  [241] 270.7 261.6 272.9 275.8 271.0 276.3 274.0 276.1 278.1 274.5 276.6 271.6
##  [253] 271.9 272.8 271.0 271.9 277.7 267.8 266.1 269.5 279.1 312.1 314.1 309.7
##  [265] 310.2 302.1 301.4 304.5 305.6 312.9 306.0 308.3 305.1 296.7 299.9 298.2
##  [277] 300.2 300.4 283.8 277.6 286.2 288.7 293.2 288.2 286.5 191.9 198.2 170.3
##  [289] 162.5 160.2 146.1 159.8 165.4 154.7 156.3 154.1 160.8 157.0 155.9 161.3
##  [301] 161.0 153.8 143.3 154.8 163.6 161.8 160.7 160.6 157.2 154.1 162.3 161.4
##  [313] 156.6 161.7 164.4 178.8 184.2 178.9 184.6 174.9 180.3 272.6 263.5 257.3
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##  [349] 265.5 267.1 272.7 268.4 271.0 268.6 266.1 270.9 279.3 312.1 308.1 305.1
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##  [373] 303.0 300.4 299.3 299.8 287.9 288.7 291.7 290.3 288.6 193.7 198.5 167.3
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##  [397] 158.6 156.2 149.8 155.3 159.4 160.1 155.2 161.5 159.8 157.4 161.1 162.0
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##  [541] 270.8 270.8 265.7 270.9 266.7 271.3 268.3 267.3 276.5 311.1 310.5 313.6
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##  [757] 303.5 304.6 292.1 283.4 284.1 281.0 284.8 287.8 293.5 196.9 193.8 168.3
```

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##  [805] 254.6 258.2 257.3 261.4 254.6 252.1 260.3 264.1 265.1 271.1 267.5 261.3
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##  [841] 312.9 300.6 307.2 303.8 307.5 313.8 306.3 298.1 302.4 304.1 306.9 307.0
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##  [985] 168.5 170.0 178.3 180.0 179.2 187.0 200.6 185.5 190.1 282.3 275.1 266.5
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## [1021] 288.1 282.5 293.9 295.8 302.5 296.7 285.1 288.2 277.1 327.0 329.9 331.2
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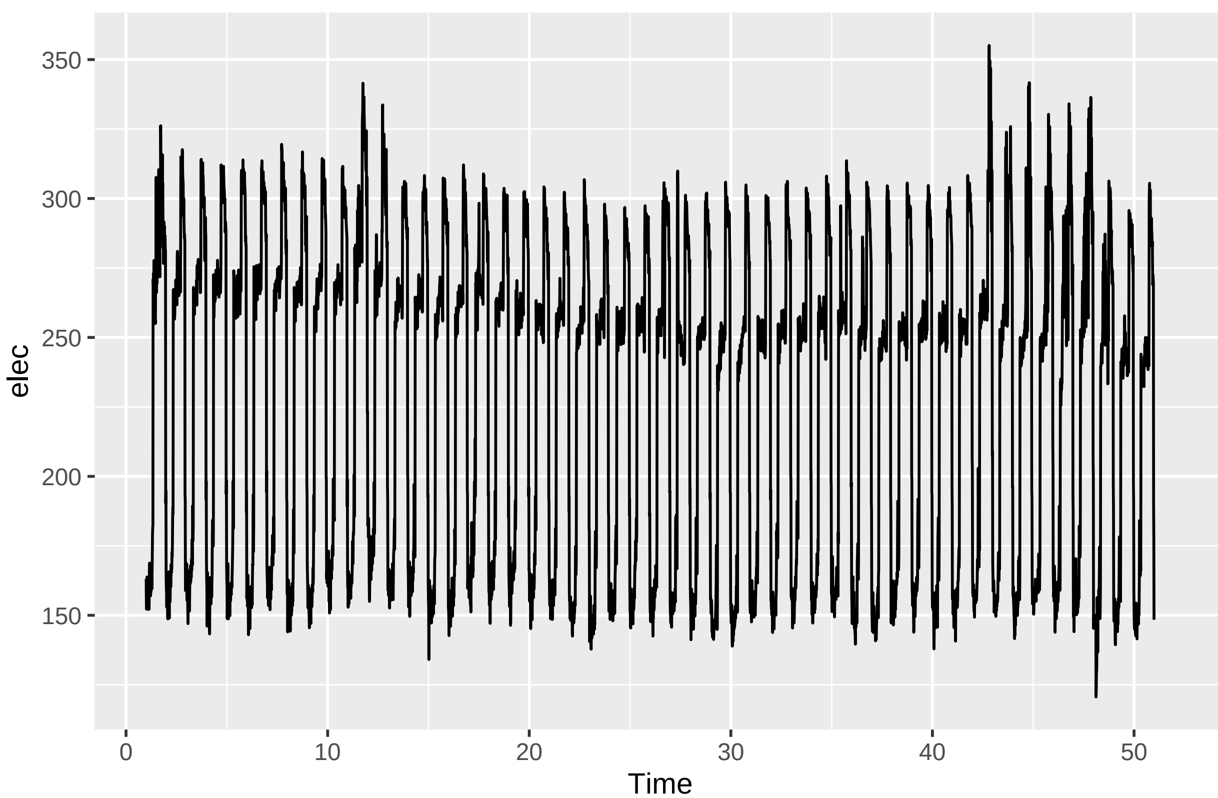
## [3469] 149.8 146.7 149.1 149.7 149.5 140.8 141.9 143.6 141.2 144.0 147.2 149.7
## [3481] 149.6 152.5 157.5 157.2 159.8 160.3 149.1 164.1 166.2 246.2 245.5 241.4
## [3493] 241.3 249.6 246.5 248.7 247.7 242.3 243.0 241.7 248.6 247.3 242.1 248.1
## [3505] 244.6 249.6 250.0 252.2 250.7 251.2 256.1 254.0 251.8 251.5 253.5 250.6
## [3517] 252.8 252.5 246.8 252.7 248.6 246.2 250.1 249.6 245.0 248.2 252.1 300.5
## [3529] 301.2 304.6 301.8 299.4 296.4 302.8 298.5 295.7 299.3 295.4 289.8 288.9
## [3541] 289.4 276.7 277.5 280.4 279.4 194.1 185.9 148.0 147.2 154.9 156.9 159.0
## [3553] 154.2 159.2 153.5 157.6 161.5 162.4 146.5 157.7 156.7 151.4 159.4 158.1
## [3565] 154.6 149.3 150.5 158.4 152.1 156.0 155.9 161.7 162.6 161.2 161.0 162.3
## [3577] 165.5 163.7 182.5 191.1 182.5 183.3 166.3 166.9 171.4 252.9 255.7 249.0
## [3589] 251.0 252.9 251.3 251.2 248.7 253.2 251.1 253.2 255.0 253.8 250.6 250.7
## [3601] 249.2 252.5 258.9 258.7 255.0 253.0 255.1 251.8 253.3 256.3 256.5 257.1
## [3613] 248.7 250.6 247.3 249.7 248.3 246.7 248.5 250.1 241.8 254.4 245.8 302.8
## [3625] 305.6 302.6 298.8 293.2 294.6 300.1 298.3 301.0 296.5 294.3 293.4 295.3
## [3637] 295.6 297.4 293.1 294.6 296.8 283.3 285.1 285.3 282.7 200.3 199.2 160.6
## [3649] 158.1 157.6 153.4 159.2 158.2 161.6 149.2 143.9 146.1 156.1 156.2 155.6
## [3661] 155.2 149.5 150.6 157.3 158.0 160.5 157.1 161.4 160.1 163.8 158.7 159.4
## [3673] 161.5 162.1 183.0 191.8 180.8 178.6 167.7 167.0 174.3 254.8 249.9 250.2
## [3685] 248.2 252.7 250.5 249.6 255.6 252.5 255.5 256.3 252.1 249.0 257.0 248.5
## [3697] 250.0 249.2 254.8 263.2 257.8 255.4 256.6 257.6 257.4 256.7 262.8 258.8
## [3709] 259.0 255.5 252.8 253.6 249.3 252.2 249.8 253.8 251.2 255.2 252.5 296.4
## [3721] 298.4 298.9 295.4 300.2 304.7 302.4 291.6 294.2 298.6 301.6 291.8 290.3
## [3733] 295.8 294.1 289.3 293.2 284.1 273.8 278.0 281.2 285.4 194.0 193.3 159.9
## [3745] 152.9 158.0 152.1 152.3 156.0 158.0 144.9 137.9 141.5 149.5 156.3 154.9
## [3757] 152.9 147.1 145.5 148.0 158.4 157.0 157.0 156.1 160.7 160.3 152.4 151.0
## [3769] 145.7 163.9 178.1 181.0 185.2 177.5 162.6 169.2 173.0 257.6 258.8 249.1
## [3781] 248.8 257.9 247.5 247.9 255.4 248.7 252.9 253.5 248.1 256.5 254.5 252.6
## [3793] 253.3 256.0 262.9 260.7 248.9 255.7 255.7 257.9 255.4 256.0 254.0 255.3
## [3805] 252.5 261.4 251.0 254.7 247.6 244.9 250.8 246.5 246.2 251.6 247.7 290.8
## [3817] 296.0 294.7 293.3 296.6 296.4 302.2 297.5 300.7 300.2 304.0 297.5 299.2
## [3829] 296.5 294.2 293.7 294.0 293.2 288.2 287.0 284.3 283.3 196.5 189.6 155.9
## [3841] 158.5 157.1 150.5 156.0 158.9 153.6 145.6 148.9 156.1 158.2 158.7 154.6
## [3853] 152.6 148.1 140.7 156.0 156.7 158.8 156.9 159.1 159.7 154.8 152.8 154.2
## [3865] 155.2 162.2 162.0 162.7 167.7 171.0 174.2 167.1 171.1 258.4 253.2 253.9
## [3877] 253.1 260.1 243.1 244.8 251.8 251.9 248.8 255.1 250.2 255.1 255.1 256.8
## [3889] 254.4 254.1 255.6 251.8 254.1 253.8 254.0 256.6 251.3 253.0 255.2 253.3
## [3901] 254.6 254.4 254.9 250.5 248.4 247.5 256.2 248.3 247.6 254.4 258.3 296.0
## [3913] 308.3 301.0 299.6 302.4 299.3 300.4 297.0 301.4 305.6 304.8 298.7 299.5
## [3925] 301.9 295.2 298.3 295.2 294.1 289.9 289.9 290.3 289.1 206.5 202.4 165.3
## [3937] 158.0 158.4 156.8 159.3 161.1 153.0 151.5 154.9 149.3 154.8 157.5 158.9
## [3949] 157.3 154.4 154.6 155.5 157.6 156.6 155.4 158.2 161.0 162.1 170.1 166.2
## [3961] 169.1 169.0 202.9 190.7 187.5 186.1 167.4 176.5 173.5 258.9 256.4 257.0
## [3973] 253.2 265.5 261.3 254.8 260.8 255.2 262.3 258.1 259.6 265.4 257.9 262.9
## [3985] 262.4 266.8 270.6 264.8 261.5 262.5 263.6 264.3 256.4 258.6 267.0 258.2
## [3997] 261.2 267.4 259.6 261.2 258.2 260.9 261.3 256.9 256.2 264.3 259.1 291.2
```

```
## [4009] 310.1 300.6 303.8 306.7 307.1 318.1 355.1 313.2 304.6 349.7 332.3 299.1
## [4021] 321.9 346.9 301.1 300.7 327.8 305.7 287.9 310.2 288.8 207.4 208.9 168.7
## [4033] 164.6 158.7 159.1 162.6 162.3 158.8 151.1 152.8 155.8 156.9 155.7 152.2
## [4045] 153.7 149.7 149.6 152.0 157.2 151.7 154.6 153.4 154.9 157.6 154.9 156.1
## [4057] 162.0 164.8 172.6 172.1 166.8 162.5 170.9 166.4 173.5 252.9 241.3 244.3
## [4069] 241.4 251.8 247.1 248.1 242.9 243.1 248.7 247.4 256.0 252.3 254.8 249.0
## [4081] 250.5 257.1 261.7 256.6 257.5 257.5 255.6 260.9 254.4 254.8 262.4 267.0
## [4093] 282.3 318.4 267.9 265.7 323.9 282.3 272.2 306.7 254.0 258.3 257.6 287.8
## [4105] 303.0 305.3 304.9 308.4 302.6 308.1 304.8 301.9 302.6 304.7 305.7 312.7
## [4117] 325.9 300.0 304.8 302.5 292.2 290.6 283.7 281.0 283.0 196.0 196.3 162.9
## [4129] 156.9 160.4 155.0 153.9 150.9 149.2 145.9 141.6 143.5 142.8 148.5 146.4
## [4141] 149.8 150.1 155.2 157.7 157.6 158.2 157.8 153.0 149.9 152.6 152.6 154.4
## [4153] 154.3 156.8 169.7 160.6 169.2 171.2 155.6 155.6 164.3 242.9 250.0 244.7
## [4165] 239.9 249.1 239.7 240.2 240.5 242.7 245.5 242.2 249.5 244.3 242.7 247.0
## [4177] 246.0 246.7 249.9 251.0 245.3 247.6 252.7 250.6 249.5 255.9 253.2 257.6
## [4189] 260.0 267.0 311.0 262.2 254.9 250.0 311.1 277.9 252.2 281.1 279.4 279.0
## [4201] 307.5 305.1 340.4 312.1 308.0 341.7 308.7 302.7 327.5 308.6 299.0 302.0
## [4213] 307.7 281.3 276.0 274.5 273.9 194.5 192.0 160.2 157.1 154.0 160.1 157.9
## [4225] 154.8 154.0 150.4 152.2 159.6 160.0 156.6 154.7 159.9 159.1 163.0 157.0
## [4237] 159.6 157.3 155.1 159.3 160.2 162.0 157.9 162.7 159.7 162.7 163.4 166.6
## [4249] 158.2 163.4 172.1 169.2 164.1 168.2 159.1 167.3 170.0 249.0 250.1 248.5
## [4261] 248.4 249.0 246.2 249.1 248.2 251.3 247.1 246.4 241.4 245.8 246.1 247.4
## [4273] 246.0 250.1 250.8 251.6 253.3 257.9 252.0 261.7 249.3 255.8 256.8 284.5
## [4285] 304.2 247.2 286.5 292.5 252.0 254.1 252.4 282.4 279.6 259.1 289.3 269.8
## [4297] 314.0 330.3 294.9 324.9 311.4 295.7 325.9 301.6 299.8 316.2 289.0 296.5
## [4309] 304.0 297.1 302.7 295.4 293.1 291.2 289.6 284.7 283.9 211.9 203.8 167.2
## [4321] 162.0 156.6 158.3 155.1 167.8 164.7 158.3 151.3 143.9 153.9 155.9 154.9
## [4333] 154.3 149.0 148.8 157.9 161.9 155.9 151.5 153.4 158.6 157.9 154.8 156.3
## [4345] 159.4 162.9 165.4 167.7 189.3 174.4 161.5 159.0 163.1 233.8 232.1 235.1
## [4357] 225.6 231.3 232.6 231.2 234.9 233.7 246.8 262.0 268.0 269.2 264.5 267.6
## [4369] 277.5 293.8 257.2 292.0 291.9 268.3 270.8 285.6 276.6 279.0 286.0 264.4
## [4381] 295.8 295.4 247.0 263.3 269.8 271.9 297.2 258.0 269.3 272.3 249.1 304.0
## [4393] 316.0 299.2 334.1 308.1 305.9 330.9 292.4 317.3 316.0 296.0 325.9 308.7
## [4405] 290.6 304.9 299.2 297.9 292.7 270.6 265.4 270.9 276.2 192.7 187.1 149.5
## [4417] 150.9 151.9 144.1 150.7 154.9 156.0 155.3 157.8 160.2 162.3 152.5 170.4
## [4429] 164.5 159.4 150.2 153.6 157.5 155.1 150.8 151.5 153.2 152.9 153.1 154.9
## [4441] 160.6 156.0 162.4 182.1 178.5 181.5 175.1 171.0 176.3 252.8 249.6 242.1
## [4453] 244.0 247.1 240.7 250.7 246.4 256.7 268.4 270.2 261.2 267.9 256.6 250.1
## [4465] 268.7 286.4 281.2 251.8 289.6 294.7 263.6 300.3 289.2 287.5 277.7 253.8
## [4477] 288.6 309.1 293.2 287.0 264.1 282.7 283.4 279.1 277.8 260.6 257.0 295.2
## [4489] 328.9 296.2 332.4 323.8 311.4 315.0 327.8 326.2 316.1 299.9 336.4 324.7
## [4501] 302.3 321.9 305.4 299.8 294.3 283.7 285.5 288.2 295.2 205.4 200.0 145.3
## [4513] 150.0 150.0 150.0 150.0 150.0 150.0 150.0 150.0 150.0 150.0 150.0 120.6
## [4525] 123.4 129.8 130.0 138.8 156.4 153.4 150.9 136.7 149.9 155.4 151.8 149.4
## [4537] 159.2 153.0 160.2 167.2 174.6 165.8 148.8 153.6 161.3 239.8 239.7 240.5
## [4549] 245.1 247.7 246.1 242.5 240.7 246.2 249.8 253.0 273.7 269.0 254.8 283.6
## [4561] 252.0 270.5 280.0 255.3 251.8 278.1 287.2 247.2 277.6 273.4 249.1 263.1
## [4573] 258.9 260.3 262.7 256.8 264.3 262.4 255.4 233.3 236.2 255.5 248.8 278.2
## [4585] 306.3 291.4 302.3 298.0 299.9 303.9 303.2 303.1 299.5 299.4 287.0 286.3
## [4597] 288.6 277.0 272.7 274.9 269.4 274.1 270.7 268.6 269.2 197.1 188.9 155.1
## [4609] 148.2 147.8 148.7 154.9 155.9 150.5 140.5 139.4 145.0 150.1 154.7 149.6
## [4621] 146.9 149.1 147.2 153.5 148.5 144.1 151.0 146.7 149.9 151.8 156.1 152.7
## [4633] 158.5 165.8 178.2 166.5 170.3 169.4 154.9 154.9 167.0 241.2 238.9 240.2
## [4645] 238.4 242.2 245.9 238.2 239.7 240.3 242.4 235.3 236.1 242.7 244.6 247.0
```

```
## [4657] 242.9 240.0 252.0 257.8 249.9 245.3 246.7 251.8 241.7 245.9 242.5 246.2
## [4669] 245.0 242.7 241.4 243.7 236.2 241.6 246.2 241.9 240.7 245.5 237.5 251.3
## [4681] 295.7 293.7 291.2 290.2 293.1 294.6 289.3 288.2 283.5 292.4 282.7 283.6
## [4693] 289.6 285.9 284.6 290.7 285.5 277.3 275.6 274.0 279.3 198.1 191.0 157.7
## [4705] 151.9 147.0 145.1 152.6 154.2 154.1 143.9 146.0 142.6 148.6 154.4 149.6
## [4717] 148.7 146.7 141.5 147.1 150.3 150.1 148.2 148.8 147.8 146.8 151.1 150.1
## [4729] 152.4 161.7 184.1 173.6 169.7 164.2 164.5 168.0 166.3 244.0 241.1 234.6
## [4741] 239.0 240.0 234.2 235.4 238.3 232.5 237.1 235.4 233.8 232.7 234.1 232.3
## [4753] 242.9 243.2 240.1 247.6 246.4 244.1 250.0 242.8 239.8 244.3 243.9 245.2
## [4765] 249.9 244.4 247.2 242.4 241.5 240.0 240.4 238.4 241.8 246.1 239.7 252.8
## [4777] 299.2 302.9 305.5 292.6 294.5 303.1 293.4 291.3 292.6 288.9 291.9 292.9
## [4789] 287.9 287.4 282.6 284.5 276.2 268.9 272.5 271.2 269.8 189.6 177.9 148.4
## [4801]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4813]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4825]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4837]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4849]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4861]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4873]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
## [4885]    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA    NA
```

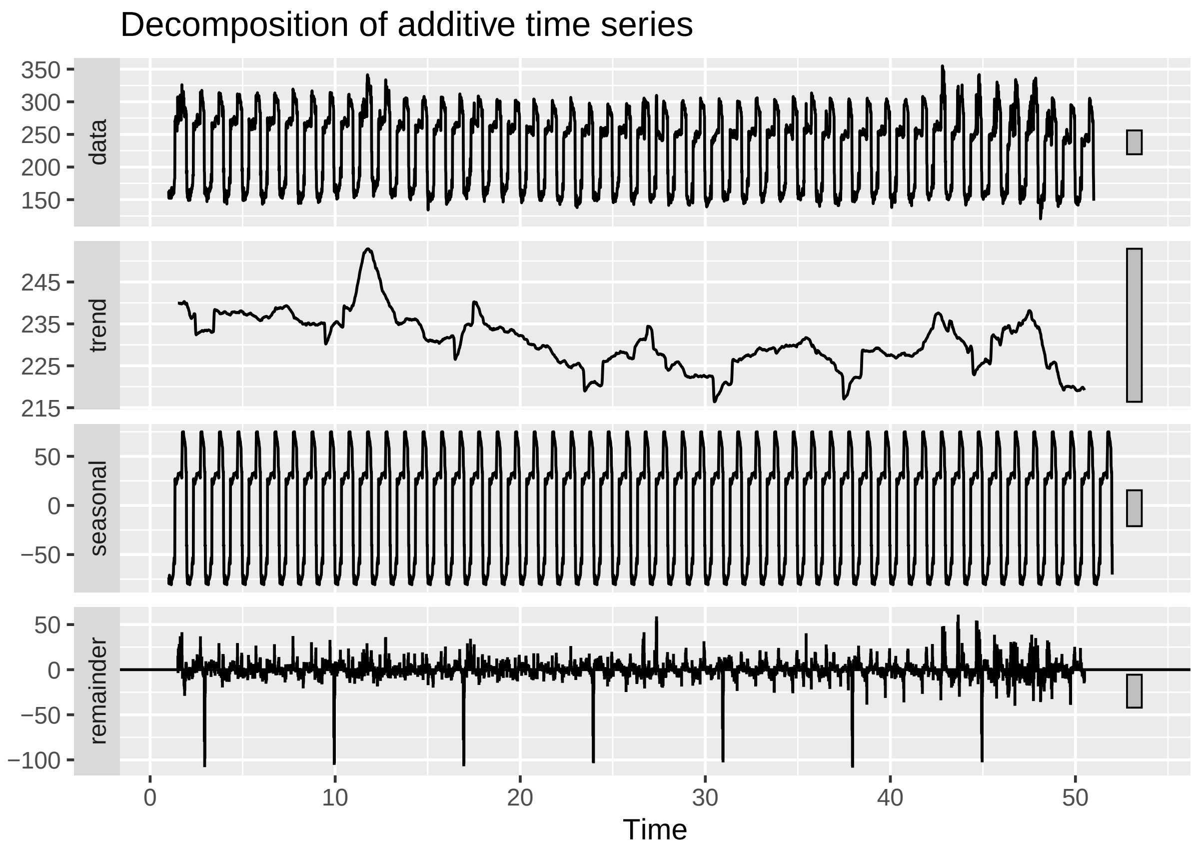
```r
autoplot(elec) # visualisation des valeurs remplacées
```



Décomposition de la Série Temporelle

On décompose la série.

```r
autoplot(decompose(elec, type="additive"))
```



Il ne semble pas y avoir de tendance. On se concentrera donc sur des modèles saisonniers.

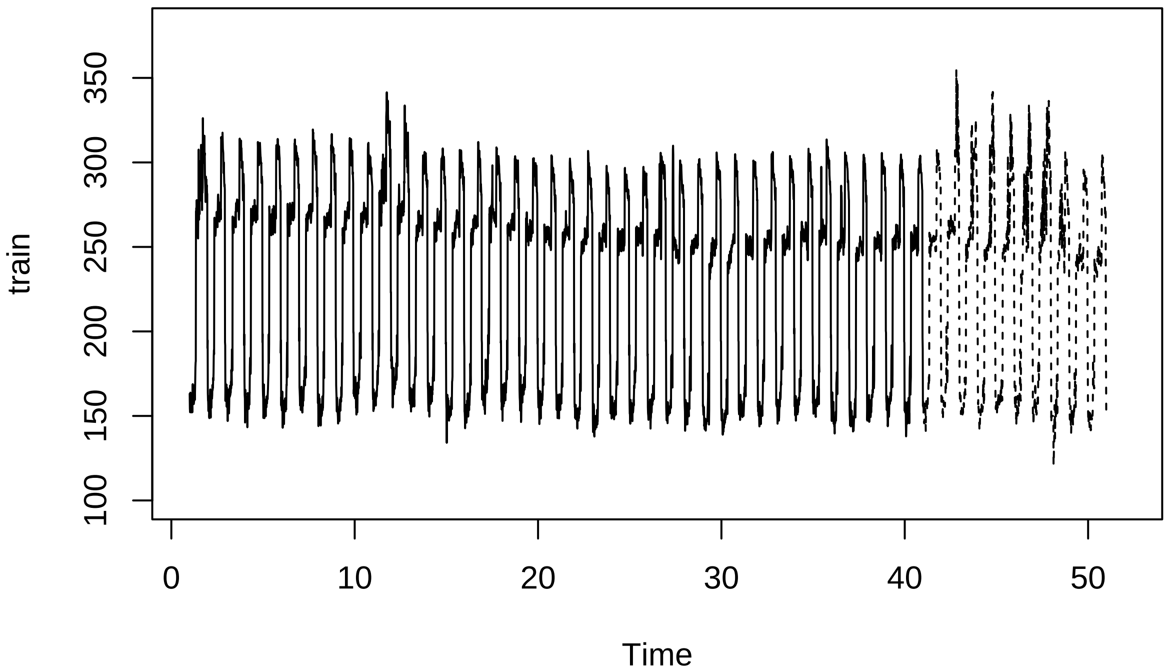
Division des Données

On divise nos données en ensembles d'apprentissage et de test pour un rapport de 80/20. L'ensemble d'apprentissage commence ainsi le premier jour du jeu de données (2 Janvier 2010) à la première heure, et se termine le quarantième jour (10 Février 2010) à la dernière heure.

```r
train <- window(elec, start=c(1,1), end=c(40,96))
test <- window(elec, start=c(41,1), end=c(50,96))
```

On affiche les 2 ensembles simultanément :

```r
plot(train, xlim=c(1,52), ylim=c(100,380))
lines(test, lty=2)
```



Lissage Exponentiel Simple

On lance un Lissage Exponentiel Simple, car la meilleure prédiction a priori est une constante.

Modélisation :

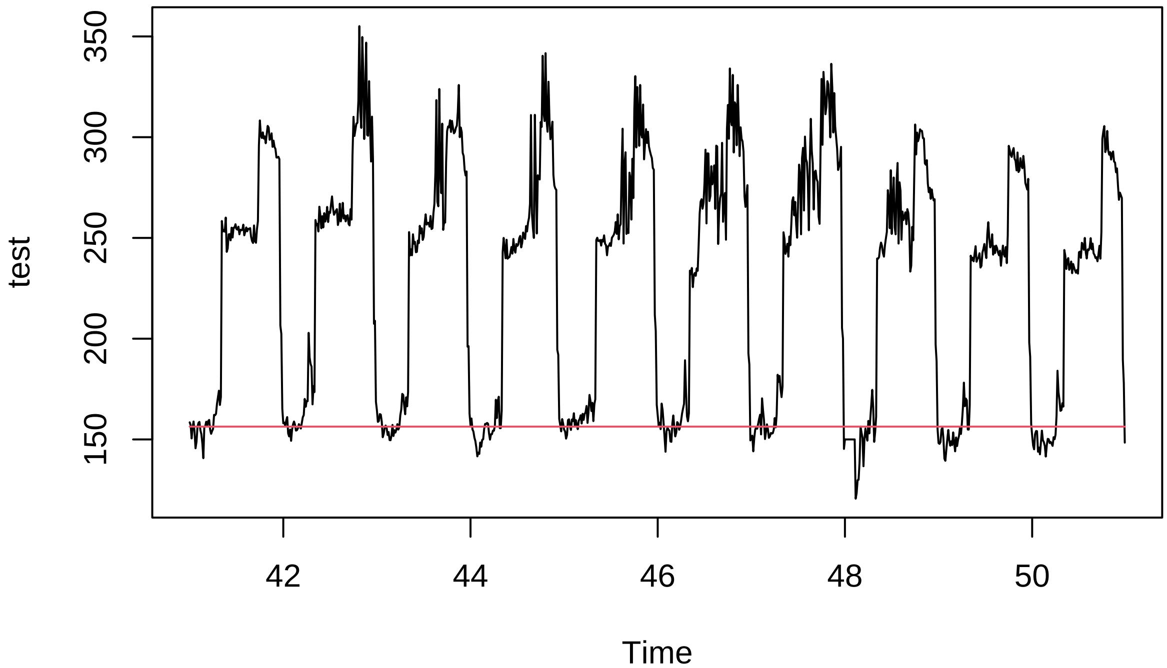
```
LES = HoltWinters(train, alpha=NULL, beta=FALSE, gamma=FALSE)
print(LES)
```

```
## Holt-Winters exponential smoothing without trend and without seasonal component.
##
## Call:
## HoltWinters(x = train, alpha = NULL, beta = FALSE, gamma = FALSE)
##
## Smoothing parameters:
##  alpha: 0.9860426
##  beta : FALSE
##  gamma: FALSE
##
## Coefficients:
##       [,1]
## a 156.3719
```

On prédit avec la constante trouvée précédemment. On constate que la moyenne, qui équivaut à la moyenne des valeurs de 'Power' est aux environs de 150. Notre valeur fixée a priori pour remplacer les valeurs nulles n'est pas absurde, bien que l'on pourrait la remplacer par la valeur exacte calculée par ce modèle.

Prédiction :

```r
pred1 <- predict(LES, n.ahead=960) # prédiction sur les 10 jours suivants
plot(test)
lines(pred1, col=2) # prédiction à partir du train set
```



Coefficient de la constante du Lissage Exponentiel Simple :

```r
print(LES$alpha) # 0.9860426
```

```
## [1] 0.9860426
```

Évaluation - RMSE du Lissage Exponentiel Simple :

```r
print(sqrt(mean((pred1-test)^2))) # 93.28624
```

```
## [1] 93.28624
```

Holt Winters Saisonnier

On lance un Holt Winters saisonnier avec une constante alpha et une saisonnalité gamma.

Modélisation :

```r
HW = HoltWinters(train, alpha=NULL, beta=FALSE, gamma=NULL) # sans tendance bêta
print(HW)
```

```
## Holt-Winters exponential smoothing without trend and with additive seasonal component.
##
## Call:
## HoltWinters(x = train, alpha = NULL, beta = FALSE, gamma = NULL)
```

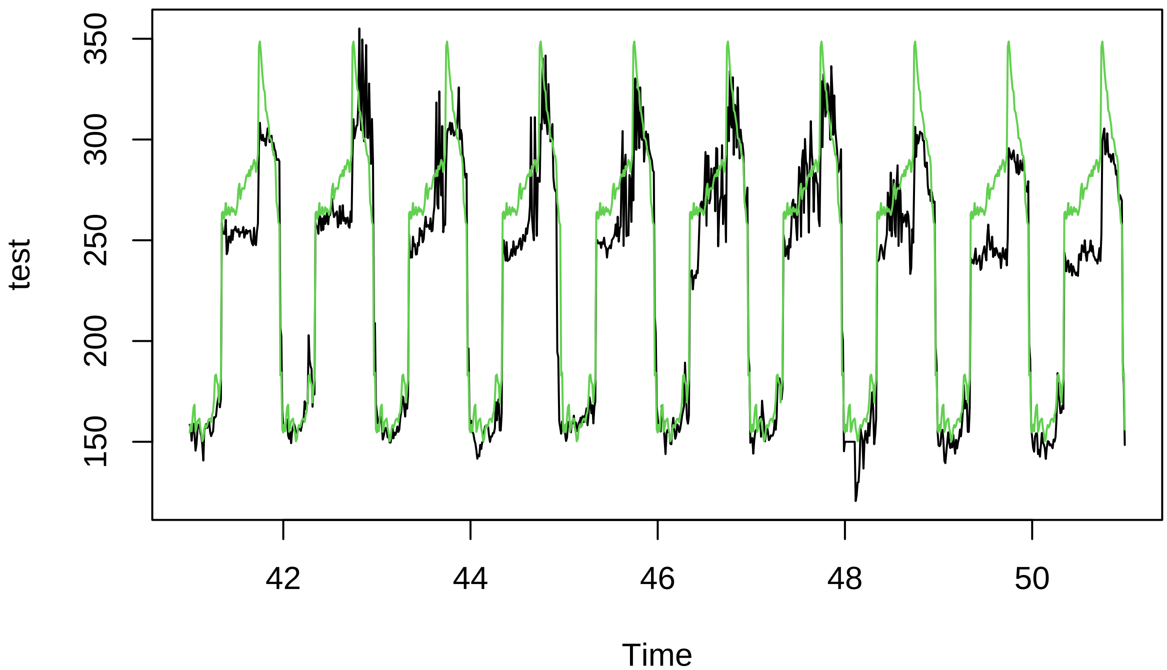
```
##
## Smoothing parameters:
##  alpha: 0.7831196
##  beta : FALSE
##  gamma: 0.8904545
##
## Coefficients:
##          [,1]
## a   240.11894
## s1  -85.53653
## s2  -81.59209
## s3  -84.89480
## s4  -78.20116
## s5  -72.88999
## s6  -71.68576
## s7  -85.21335
## s8  -83.36854
## s9  -79.97476
## s10 -79.19373
## s11 -78.56924
## s12 -83.33520
## s13 -85.83806
## s14 -89.88809
## s15 -88.66898
## s16 -83.77997
## s17 -81.77421
## s18 -82.99303
## s19 -81.97842
## s20 -79.56752
## s21 -78.70675
## s22 -78.71416
## s23 -80.33166
## s24 -76.59747
## s25 -75.18980
## s26 -68.89655
## s27 -57.44692
## s28 -56.74519
## s29 -60.28571
## s30 -61.69323
## s31 -70.64407
## s32 -63.30628
## s33 -58.80193
## s34  23.24709
## s35  24.12167
## s36  20.54998
## s37  22.51192
## s38  28.38224
## s39  22.49509
## s40  23.29417
## s41  26.44203
## s42  22.38805
## s43  24.39604
## s44  26.29052
## s45  24.03414
```

```
## s46  25.34776
## s47  24.20117
## s48  22.40583
## s49  24.49166
## s50  27.72696
## s51  35.45720
## s52  37.98888
## s53  30.40060
## s54  34.20281
## s55  35.84587
## s56  35.46848
## s57  35.39524
## s58  38.46045
## s59  41.43965
## s60  42.53769
## s61  41.54371
## s62  44.69122
## s63  41.75707
## s64  46.65363
## s65  45.10486
## s66  47.29578
## s67  49.76163
## s68  48.48894
## s69  43.75145
## s70  47.81166
## s71  52.60843
## s72 105.88779
## s73 108.53680
## s74 103.49910
## s75  95.49748
## s76  89.73647
## s77  84.74433
## s78  83.48915
## s79  74.42472
## s80  73.32390
## s81  70.05516
## s82  67.09232
## s83  60.54797
## s84  60.42753
## s85  59.10355
## s86  55.27885
## s87  52.05517
## s88  51.74057
## s89  47.41802
## s90  29.00408
## s91  25.76486
## s92  18.88309
## s93  17.50113
## s94 -57.21982
## s95 -55.69980
## s96 -84.05392
```

On voit bien les 96 périodes de la saisonnalité.

Prédiction :

```r
pred2 <- predict(HW, n.ahead=960)
plot(test)
lines(pred2, col=3) # prédiction à partir du train set
```



A priori, ce modèle n'est pas si mauvais.

Coefficients de la constante et de la saisonnalité du Holt Winters :

```r
print(HW$alpha) # 0.7831196
```

```
##     alpha
## 0.7831196
```

```r
print(HW$gamma) # 0.8904545
```

```
##     gamma
## 0.8904545
```

Évaluation - RMSE du Holt Winters saisonnier :

```r
print(sqrt(mean((pred2-test)^2))) # 21.26563
```

```
## [1] 21.26563
```

Auto-ARIMA

Après avoir lancé les modèles a priori, on continue avec un auto-ARIMA pour trouver le meilleur modèle théorique.

Modélisation :

```r
model3 = auto.arima(train)
summary(model3)
```

```
## Series: train
## ARIMA(1,0,0)(0,1,0)[96]
##
## Coefficients:
##          ar1
##       0.7815
## s.e.  0.0102
##
## sigma^2 = 95.46:  log likelihood = -13846.39
## AIC=27696.77   AICc=27696.77   BIC=27709.23
##
## Training set error measures:
##                       ME     RMSE      MAE        MPE     MAPE      MASE
## Training set -0.06254446 9.646271 5.620404 -0.1185649 2.611593 0.7134771
##                      ACF1
## Training set 0.0003086627
```

L'auto-ARIMA nous donne un SARIMA d'ordre 1, , et de période 96.

Prédiction :

```r
pred3 = forecast(model3, h=960)
```

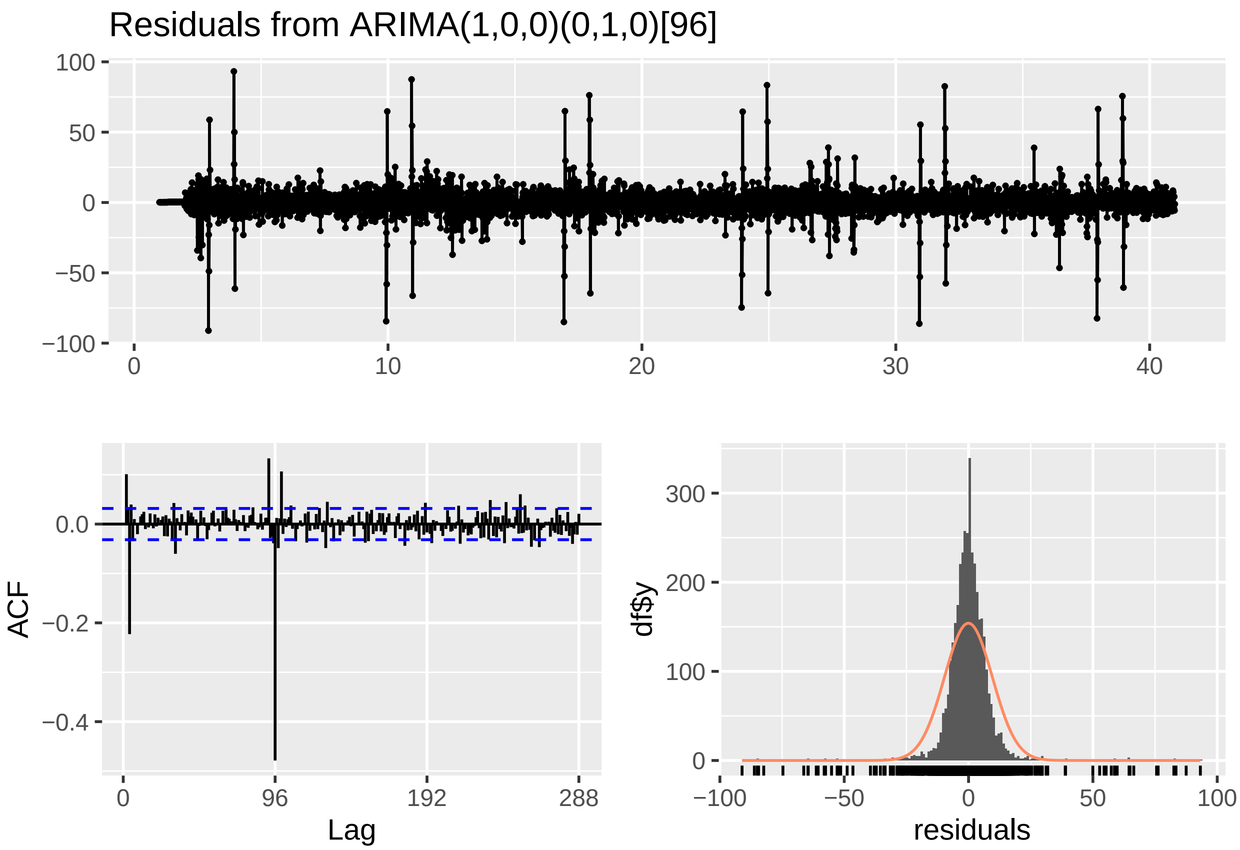
RMSE de l'ARIMA :

```r
print(sqrt(mean((pred3$mean-test)^2))) # 15.71738
```

```
## [1] 15.71738
```

Notre modèle généré par l'auto-ARIMA est le meilleur jusqu'ici des 3 créés. Mais nous devons maintenant nous assurer que les résidus de la série sont indépendants du passé.

```r
checkresiduals(model3)
```



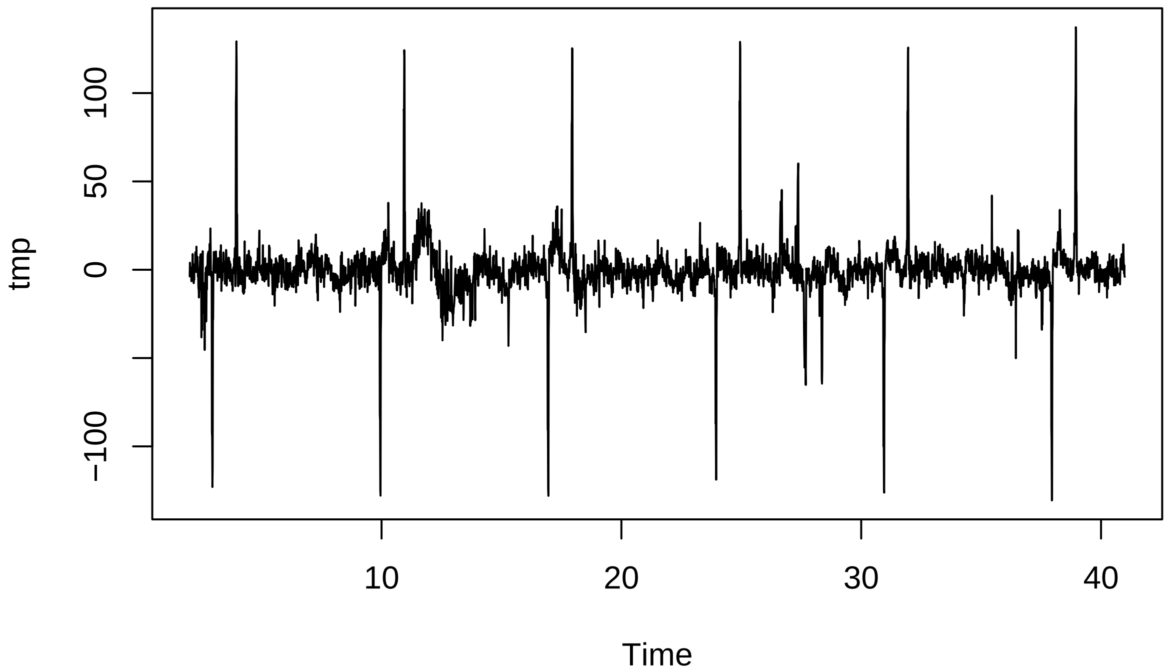

```
##
##  Ljung-Box test
##
## data:  Residuals from ARIMA(1,0,0)(0,1,0)[96]
## Q* = 1522.8, df = 191, p-value < 2.2e-16
##
## Model df: 1.   Total lags used: 192
```

Les résidus ne sont donc pas indépendants. Nous devons par conséquent différencier la série afin d'extraire les résidus et les rendre indépendants.

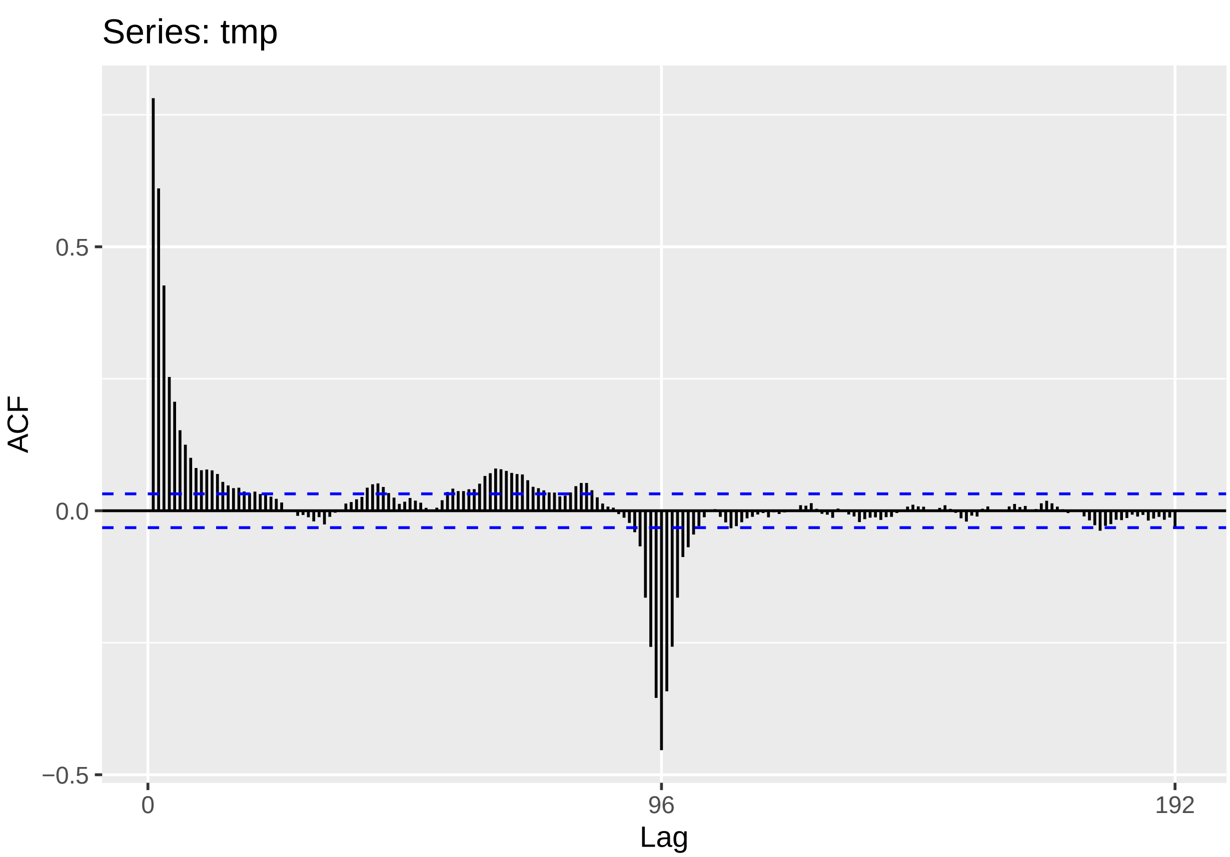
Suppression Saisonnalité

Il faudrait supprimer la saisonnalité de la série temporelle afin de pouvoir lancer un SARIMA.Pour cela, il faudrait différencier la série avec un lag spécifique. Il faudrait également calculer les auto-corrélations (ggAcf) et les auto-corrélations partielles (ggPacf) pour trouver l'ordre du SARIMA. Il faudrait également s'assurer de l'indépendance des résidus avec un box-test : les résidus sont-ils du bruit blanc ?

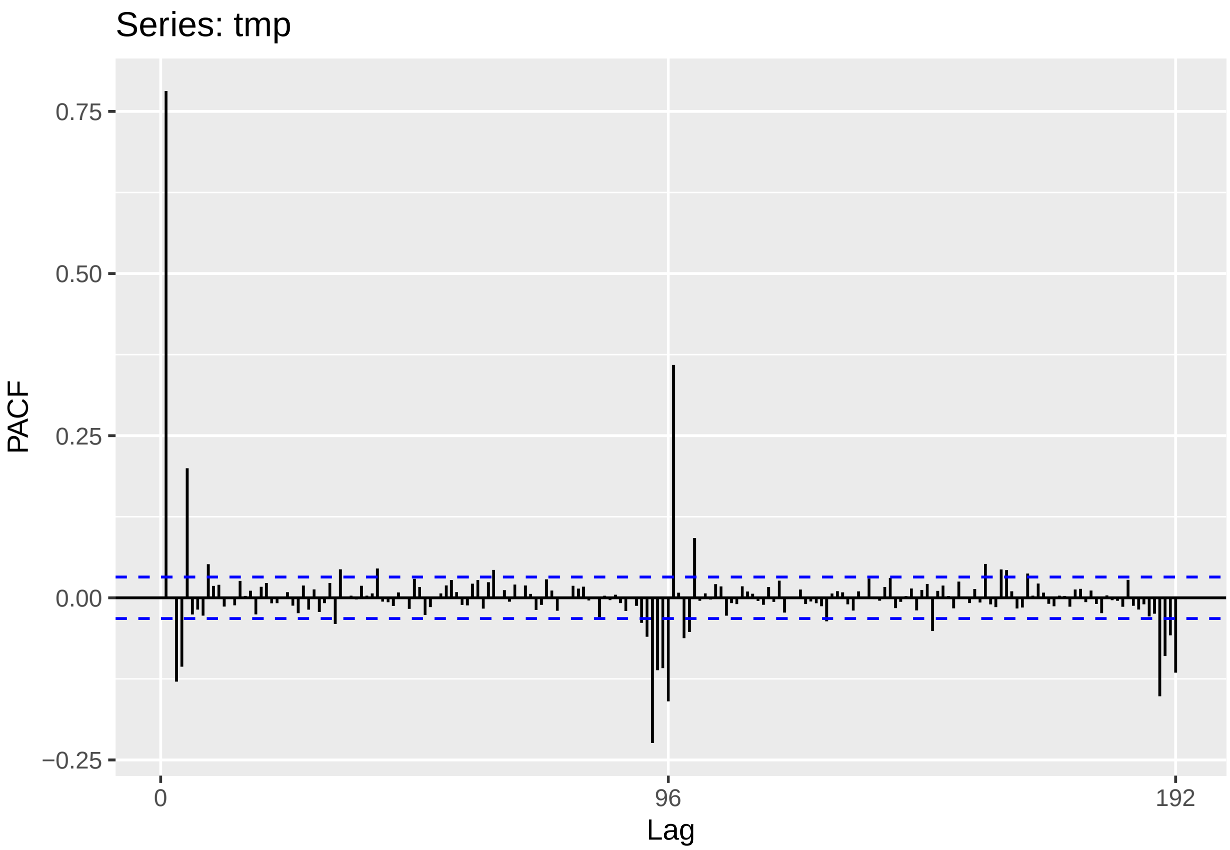
```
tmp = diff(train, lag=96)
plot(tmp)
```




```r
ggAcf(tmp)
```

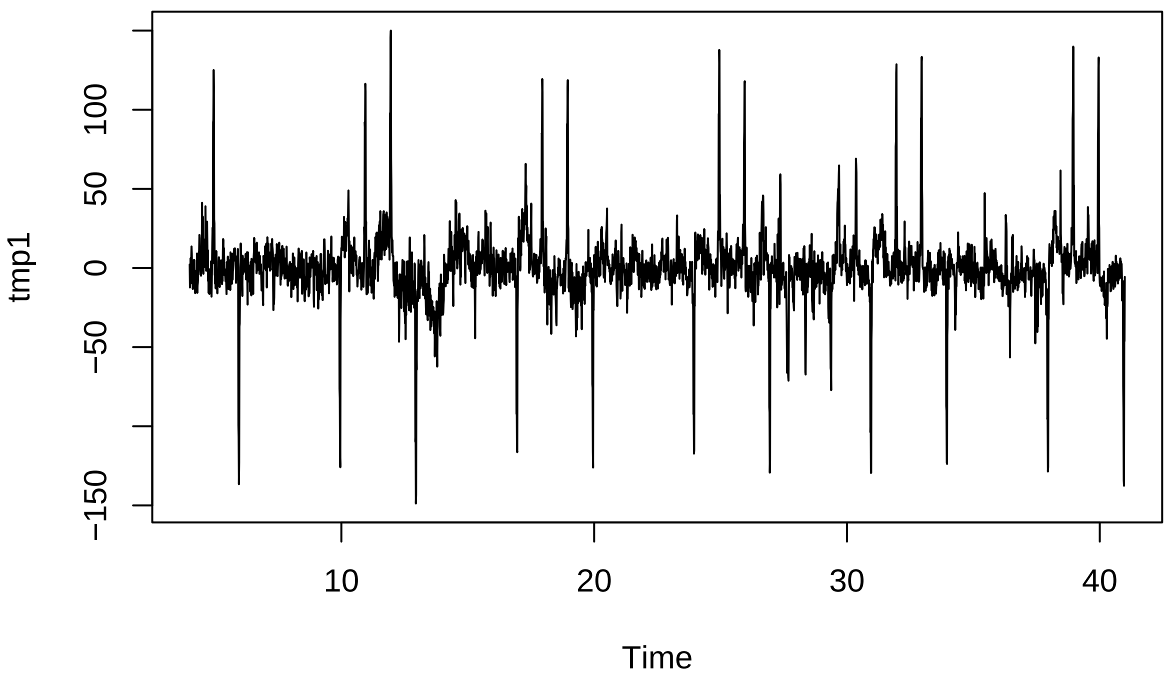



```r
ggPacf(tmp)
```

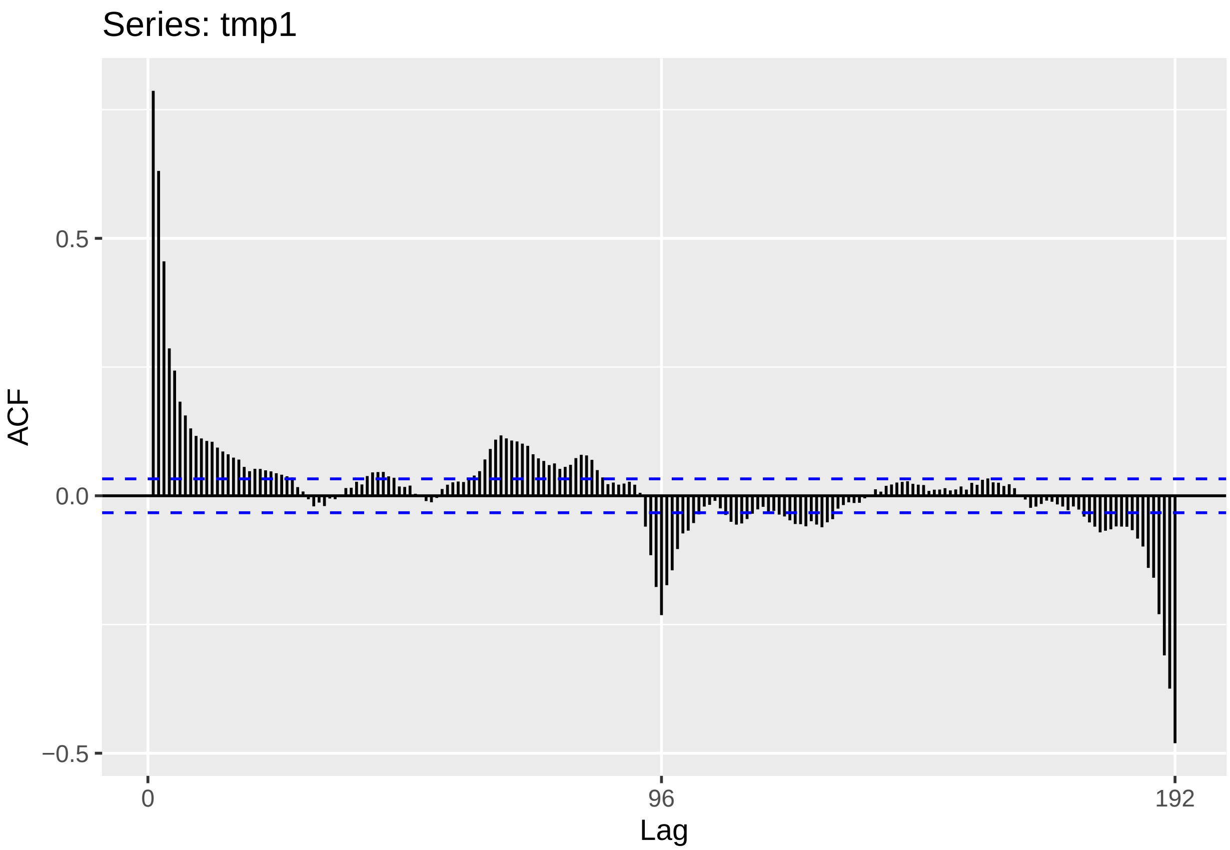


On constate que les résidus ne sont pas indépendants après une différenciation de la série.

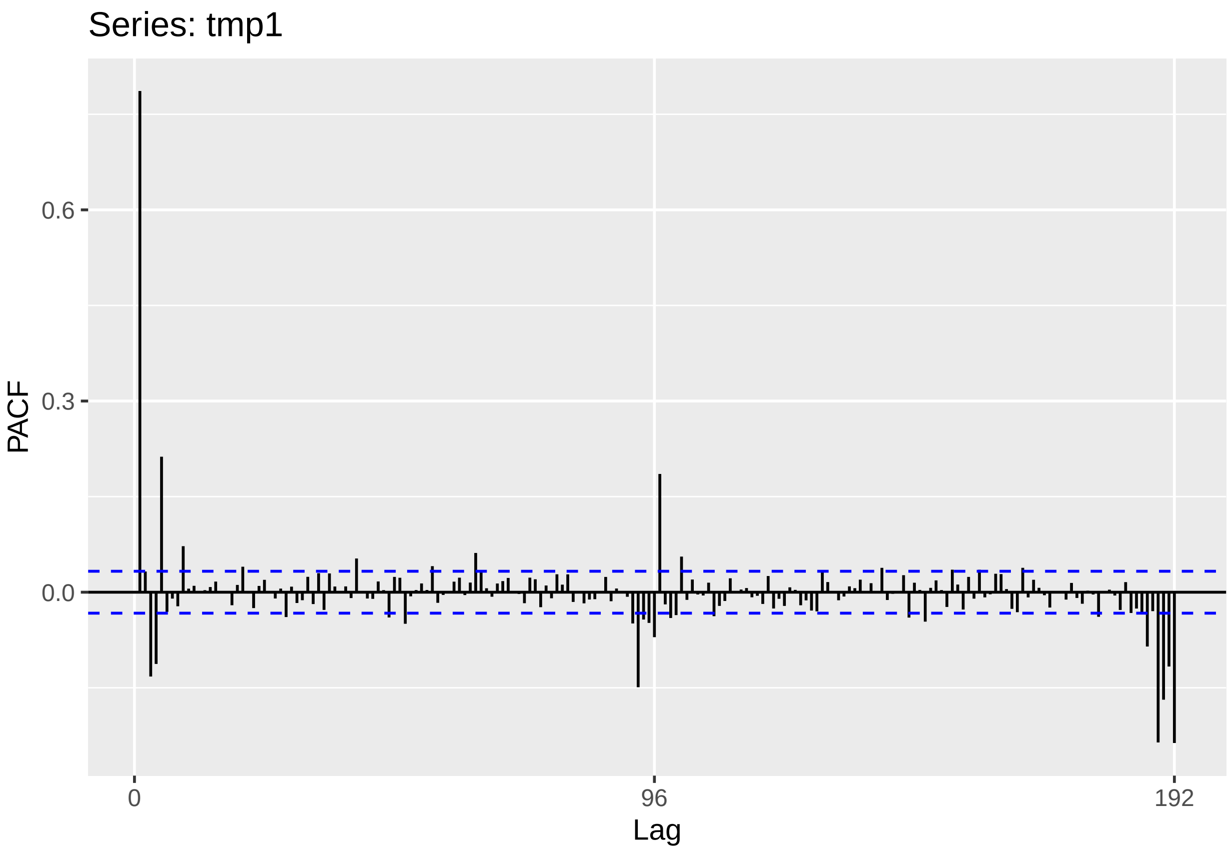
```
tmp1 = diff(tmp, lag=192)
plot(tmp1)
```



```r
ggAcf(tmp1)
```




```r
ggPacf(tmp1)
```



Après avoir rendu les résidus de la série indépendants, nous pouvons lancer un SARIMA avec les paramètres trouvés précédemment, ainsi que d'autres modèles.

Réseaux de Neurones

Modélisation :

```
model4 = nnetar(train)
print(model4)
```

```
## Series: train
## Model:  NNAR(20,1,11)[96]
## Call:   nnetar(y = train)
##
## Average of 20 networks, each of which is
## a 21-11-1 network with 254 weights
## options were - linear output units
##
## sigma^2 estimated as 48.09
```

Prédiction :

```
pred4 = forecast(model4, h=960)
```

Évaluation :

```
print(sqrt(mean((pred4$mean-test)^2)))
```

```
## [1] 77.19449
```

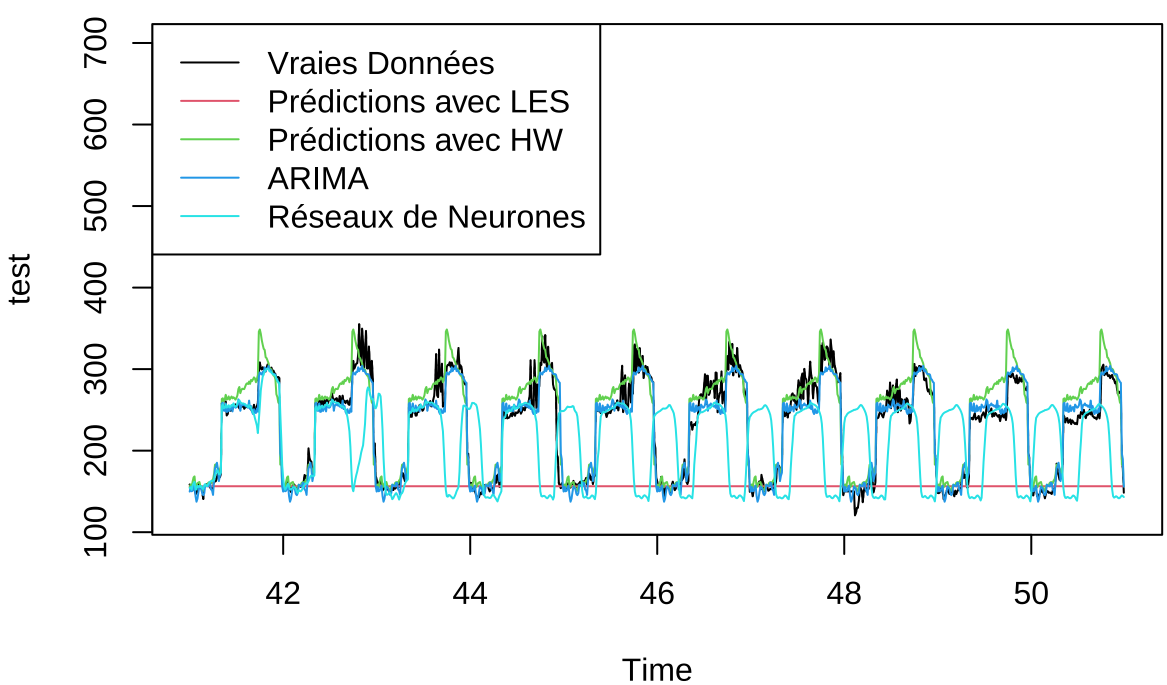
Les réseaux de neurones ne sont pas très bon, probablement parce que notre série n'est pas stationnaire.

Comparaison de Modèles

Nous insérons un graphique qui affiche simultanément chaque prédiction.

```
par(mfrow=c(1,1))

plot(test, xlim=c(41,51), ylim=c(120,700))
lines(test, lty=2)
lines(pred1, col=2)
lines(pred2, col=3)
lines(pred3$mean, col=4)
lines(pred4$mean, col=5)
legend('topleft',
       col=1:5,
       lty=1,
       legend=c('Vraies Données',
                'Prédictions avec LES',
                'Prédictions avec HW',
                'ARIMA',
                'Réseaux de Neurones'))
```



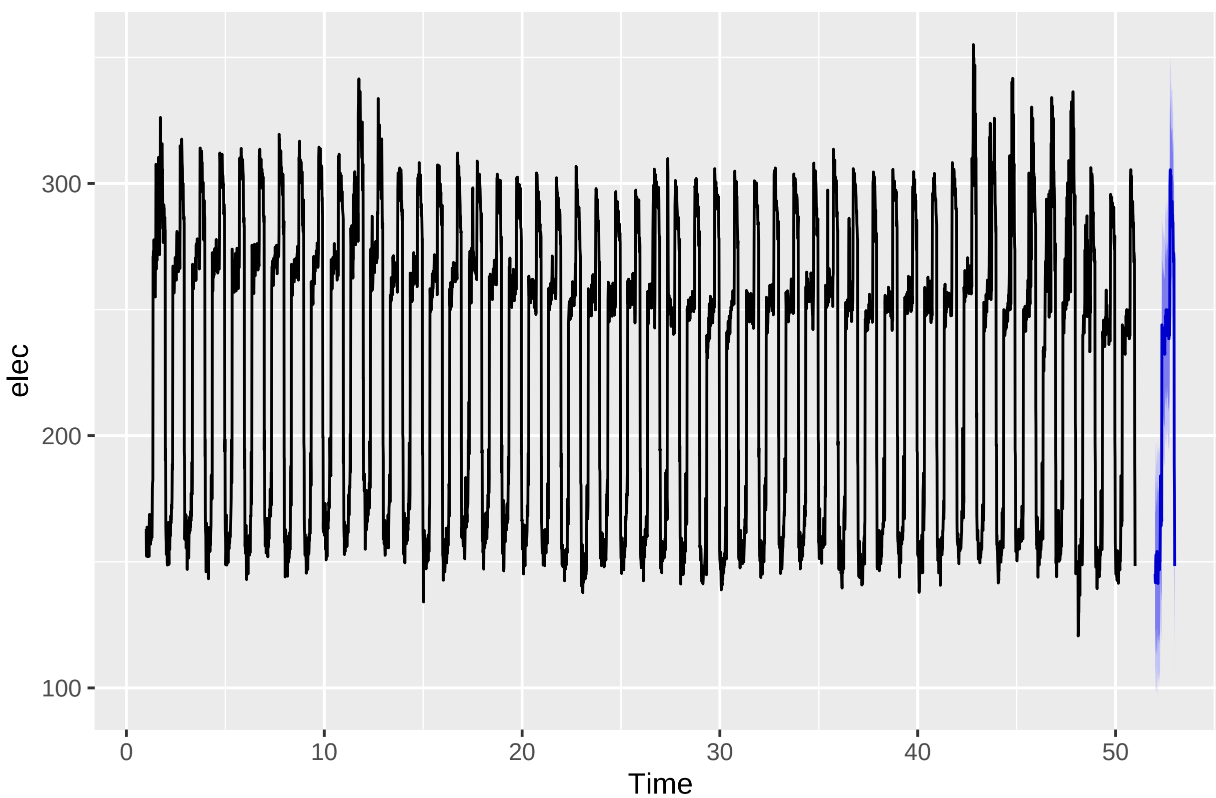
Prédiction avec le Meilleur Modèle

```r
SAR = Arima(elec, order=c(1,0,0), seasonal=c(0,1,0))
summary(SAR)
```

```
## Series: elec
## ARIMA(1,0,0)(0,1,0)[96]
##
## Coefficients:
##          ar1
##       0.7164
## s.e.  0.0102
##
## sigma^2 = 128.3:  log likelihood = -18092.79
## AIC=36189.58   AICc=36189.58   BIC=36202.49
##
## Training set error measures:
##                      ME     RMSE      MAE        MPE     MAPE      MASE
## Training set -0.1144681 11.21379 6.400623 -0.1672996 2.887978 0.7451869
##                     ACF1
## Training set -0.0708581
```

```r
pred = forecast(SAR, h=96)

autoplot(elec)+autolayer(pred)
```



```r
#predictions <- as.numeric(pred$mean)
#pred_df <- data.frame(Prediction = predictions)
```

Séries Multivariées

Ici, nous tentons de prédire la consommation d'électricité avec la température comme covariable.

Division des Données

```r
power <- ts(newdata$`Power (kW)`, start=c(1,6), end=c(51,96), freq=96)
temperature <- ts(newdata$`Temp (C°)`, start=c(1,6), end=c(51,96), freq=96)

power_train <- window(power, start=c(1,1), end=c(40,96))
```

```
## Warning in window.default(x, ...): 'start' value not changed
```

```r
power_test <- window(power, start=c(41,1), end=c(50,96))

temperature_train <- window(temperature, start=c(1,1), end=c(40,96))
```

```
## Warning in window.default(x, ...): 'start' value not changed
```

```r
temperature_test <- window(temperature, start=c(41,1), end=c(50,96))
```

Régression linéaire sans tendance et saisonnalité

Nous lançons des modèles a priori pour voir le lien entre les 2 variables.

```r
fit1 = tslm(power_train ~ temperature_train)
summary(fit1)
```

```
##
## Call:
## tslm(formula = power_train ~ temperature_train)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -121.545  -42.092    2.155   43.037  111.973
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       126.0818     3.4186   36.88   <2e-16 ***
## temperature_train   9.9478     0.3137   31.71   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 50.83 on 3833 degrees of freedom
## Multiple R-squared:  0.2078, Adjusted R-squared:  0.2076
## F-statistic:  1005 on 1 and 3833 DF,  p-value: < 2.2e-16
```

Régression linéaire avec tendance et saisonnalité

```r
fit2 = tslm(power_train ~ temperature_train+season+trend)
summary(fit2)
```

```
##
## Call:
## tslm(formula = power_train ~ temperature_train + season + trend)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -112.032   -4.617    0.248    4.591   58.331
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        2.611e+02  2.092e+00 124.776  < 2e-16 ***
## temperature_train  1.039e+00  9.814e-02  10.589  < 2e-16 ***
## season2            1.107e+00  2.622e+00   0.422  0.67291
## season3           -7.446e+01  2.623e+00 -28.392  < 2e-16 ***
## season4           -7.221e+01  2.623e+00 -27.533  < 2e-16 ***
## season5           -1.013e+02  2.623e+00 -38.632  < 2e-16 ***
## season6           -1.044e+02  2.606e+00 -40.074  < 2e-16 ***
## season7           -1.050e+02  2.607e+00 -40.273  < 2e-16 ***
## season8           -1.111e+02  2.607e+00 -42.637  < 2e-16 ***
## season9           -1.048e+02  2.607e+00 -40.206  < 2e-16 ***
## season10          -1.016e+02  2.607e+00 -38.978  < 2e-16 ***
## season11          -1.012e+02  2.607e+00 -38.801  < 2e-16 ***
## season12          -1.108e+02  2.607e+00 -42.478  < 2e-16 ***
## season13          -1.109e+02  2.607e+00 -42.526  < 2e-16 ***
## season14          -1.075e+02  2.607e+00 -41.237  < 2e-16 ***
## season15          -1.083e+02  2.608e+00 -41.515  < 2e-16 ***
## season16          -1.055e+02  2.608e+00 -40.448  < 2e-16 ***
## season17          -1.063e+02  2.608e+00 -40.754  < 2e-16 ***
## season18          -1.048e+02  2.608e+00 -40.180  < 2e-16 ***
## season19          -1.093e+02  2.609e+00 -41.915  < 2e-16 ***
## season20          -1.107e+02  2.609e+00 -42.453  < 2e-16 ***
## season21          -1.052e+02  2.609e+00 -40.317  < 2e-16 ***
## season22          -1.036e+02  2.609e+00 -39.729  < 2e-16 ***
## season23          -1.046e+02  2.610e+00 -40.084  < 2e-16 ***
## season24          -1.056e+02  2.610e+00 -40.447  < 2e-16 ***
## season25          -1.039e+02  2.610e+00 -39.824  < 2e-16 ***
## season26          -1.041e+02  2.610e+00 -39.901  < 2e-16 ***
## season27          -1.032e+02  2.611e+00 -39.523  < 2e-16 ***
## season28          -1.022e+02  2.611e+00 -39.139  < 2e-16 ***
## season29          -1.002e+02  2.611e+00 -38.380  < 2e-16 ***
## season30          -1.008e+02  2.611e+00 -38.625  < 2e-16 ***
## season31          -9.727e+01  2.611e+00 -37.255  < 2e-16 ***
## season32          -9.022e+01  2.611e+00 -34.552  < 2e-16 ***
## season33          -8.799e+01  2.611e+00 -33.698  < 2e-16 ***
## season34          -8.752e+01  2.611e+00 -33.520  < 2e-16 ***
## season35          -8.208e+01  2.611e+00 -31.435  < 2e-16 ***
## season36          -8.259e+01  2.611e+00 -31.628  < 2e-16 ***
## season37          -8.801e+01  2.611e+00 -33.707  < 2e-16 ***
```

```
## season38           -8.436e+01  2.611e+00 -32.309  < 2e-16 ***
## season39           -3.692e-01  2.611e+00  -0.141  0.88754    
## season40           -2.332e+00  2.611e+00  -0.893  0.37177    
## season41           -5.300e+00  2.611e+00  -2.030  0.04242 *  
## season42           -5.585e+00  2.611e+00  -2.139  0.03247 *  
## season43           -2.926e+00  2.606e+00  -1.123  0.26159    
## season44           -7.947e+00  2.606e+00  -3.049  0.00231 ** 
## season45           -5.467e+00  2.606e+00  -2.098  0.03600 *  
## season46           -4.552e+00  2.606e+00  -1.747  0.08077 .  
## season47           -8.393e+00  2.607e+00  -3.220  0.00129 ** 
## season48           -7.586e+00  2.607e+00  -2.910  0.00364 ** 
## season49           -5.989e+00  2.607e+00  -2.297  0.02166 *  
## season50           -5.814e+00  2.607e+00  -2.230  0.02579 *  
## season51           -3.773e+00  2.611e+00  -1.445  0.14846    
## season52           -5.596e+00  2.611e+00  -2.144  0.03214 *  
## season53           -5.069e+00  2.611e+00  -1.942  0.05226 .  
## season54           -4.369e+00  2.611e+00  -1.674  0.09429 .  
## season55           -4.660e+00  2.618e+00  -1.780  0.07508 .  
## season56           -1.243e+00  2.618e+00  -0.475  0.63483    
## season57           -2.054e+00  2.617e+00  -0.785  0.43275    
## season58           -3.919e+00  2.617e+00  -1.497  0.13442    
## season59           -2.328e+00  2.623e+00  -0.888  0.37486    
## season60           -1.916e+00  2.623e+00  -0.730  0.46520    
## season61           -2.651e+00  2.623e+00  -1.011  0.31220    
## season62           -3.351e+00  2.623e+00  -1.278  0.20140    
## season63           -3.150e+00  2.628e+00  -1.199  0.23062    
## season64           -2.996e+00  2.628e+00  -1.140  0.25431    
## season65           -3.221e+00  2.628e+00  -1.226  0.22032    
## season66           -3.431e+00  2.628e+00  -1.306  0.19165    
## season67           -3.417e+00  2.628e+00  -1.300  0.19364    
## season68           -4.117e+00  2.628e+00  -1.567  0.11729    
## season69           -4.015e+00  2.628e+00  -1.528  0.12666    
## season70           -4.161e+00  2.628e+00  -1.583  0.11349    
## season71           -3.996e+00  2.623e+00  -1.523  0.12781    
## season72           -3.411e+00  2.623e+00  -1.300  0.19359    
## season73           -5.951e+00  2.623e+00  -2.269  0.02335 *  
## season74           -6.469e+00  2.623e+00  -2.466  0.01370 *  
## season75            1.426e+01  2.616e+00   5.450 5.35e-08 ***
## season76            2.826e+01  2.616e+00  10.803  < 2e-16 ***
## season77            4.055e+01  2.616e+00  15.504  < 2e-16 ***
## season78            4.002e+01  2.616e+00  15.299  < 2e-16 ***
## season79            3.773e+01  2.610e+00  14.457  < 2e-16 ***
## season80            3.584e+01  2.610e+00  13.733  < 2e-16 ***
## season81            3.467e+01  2.610e+00  13.284  < 2e-16 ***
## season82            3.599e+01  2.610e+00  13.789  < 2e-16 ***
## season83            4.104e+01  2.608e+00  15.734  < 2e-16 ***
## season84            3.676e+01  2.608e+00  14.094  < 2e-16 ***
## season85            3.645e+01  2.608e+00  13.974  < 2e-16 ***
## season86            3.445e+01  2.608e+00  13.210  < 2e-16 ***
## season87            3.413e+01  2.607e+00  13.091  < 2e-16 ***
## season88            3.258e+01  2.607e+00  12.497  < 2e-16 ***
## season89            3.196e+01  2.607e+00  12.259  < 2e-16 ***
## season90            3.130e+01  2.607e+00  12.006  < 2e-16 ***
## season91            2.991e+01  2.606e+00  11.476  < 2e-16 ***
```

```
## season92           2.785e+01  2.606e+00  10.687  < 2e-16 ***
## season93           2.742e+01  2.606e+00  10.520  < 2e-16 ***
## season94           2.546e+01  2.606e+00   9.768  < 2e-16 ***
## season95           7.612e+00  2.606e+00   2.921  0.00351 **
## season96           6.379e+00  2.606e+00   2.448  0.01441 *
## trend             -4.632e-03  1.737e-04 -26.664  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 11.58 on 3737 degrees of freedom
## Multiple R-squared:  0.9599, Adjusted R-squared:  0.9589
## F-statistic: 922.4 on 97 and 3737 DF,  p-value: < 2.2e-16
```

Validation croisée des 2 régressions linéaires précédentes :

```r
CV(fit1)
```

```
##           CV          AIC         AICc          BIC        AdjR2
## 2.584402e+03 3.013516e+04 3.013516e+04 3.015391e+04 2.075976e-01
```

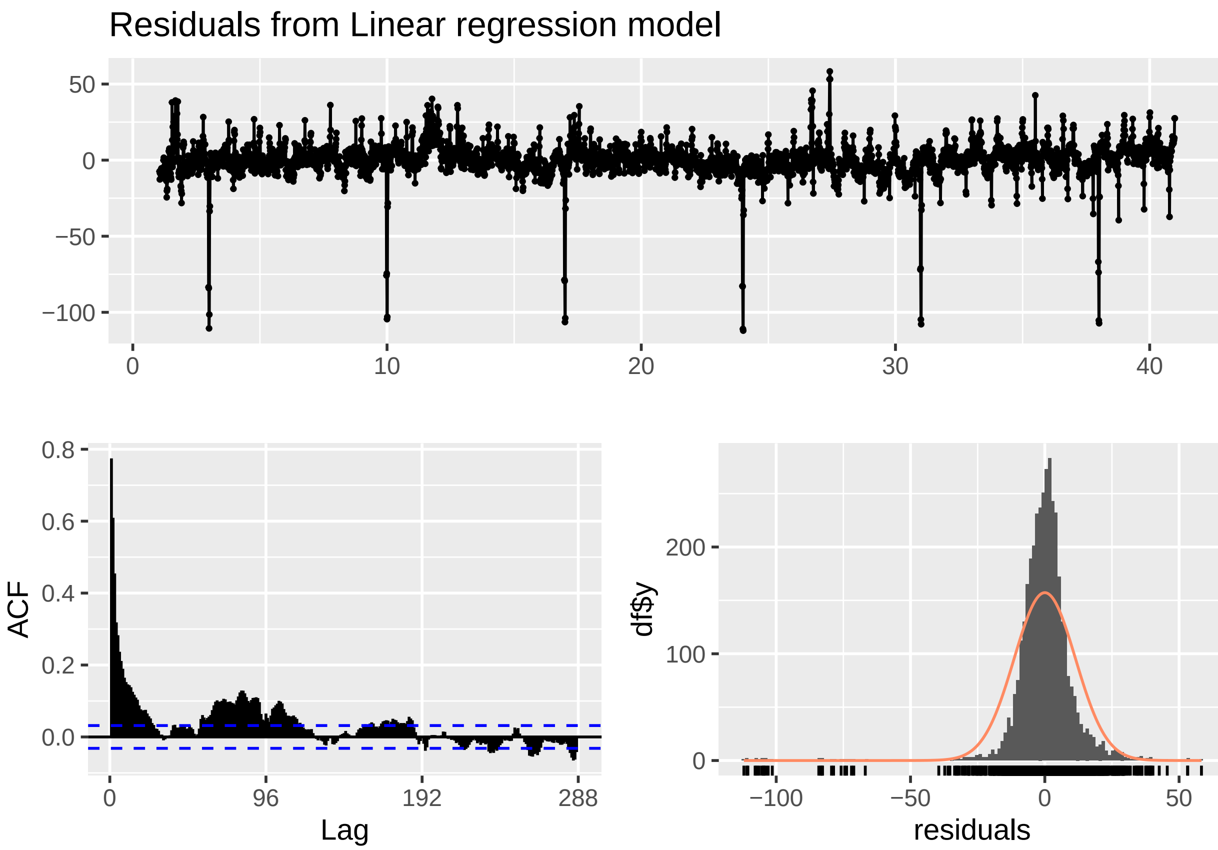
```r
CV(fit2) # BIC meilleur
```

```
##           CV          AIC         AICc          BIC        AdjR2
## 1.376823e+02 1.888504e+04 1.889034e+04 1.950398e+04 9.588661e-01
```

La deuxième a le meilleur BIC. On préfèrera donc le modèle de régression linéaire avec tendance et saisonnalité.

Check des résidus :

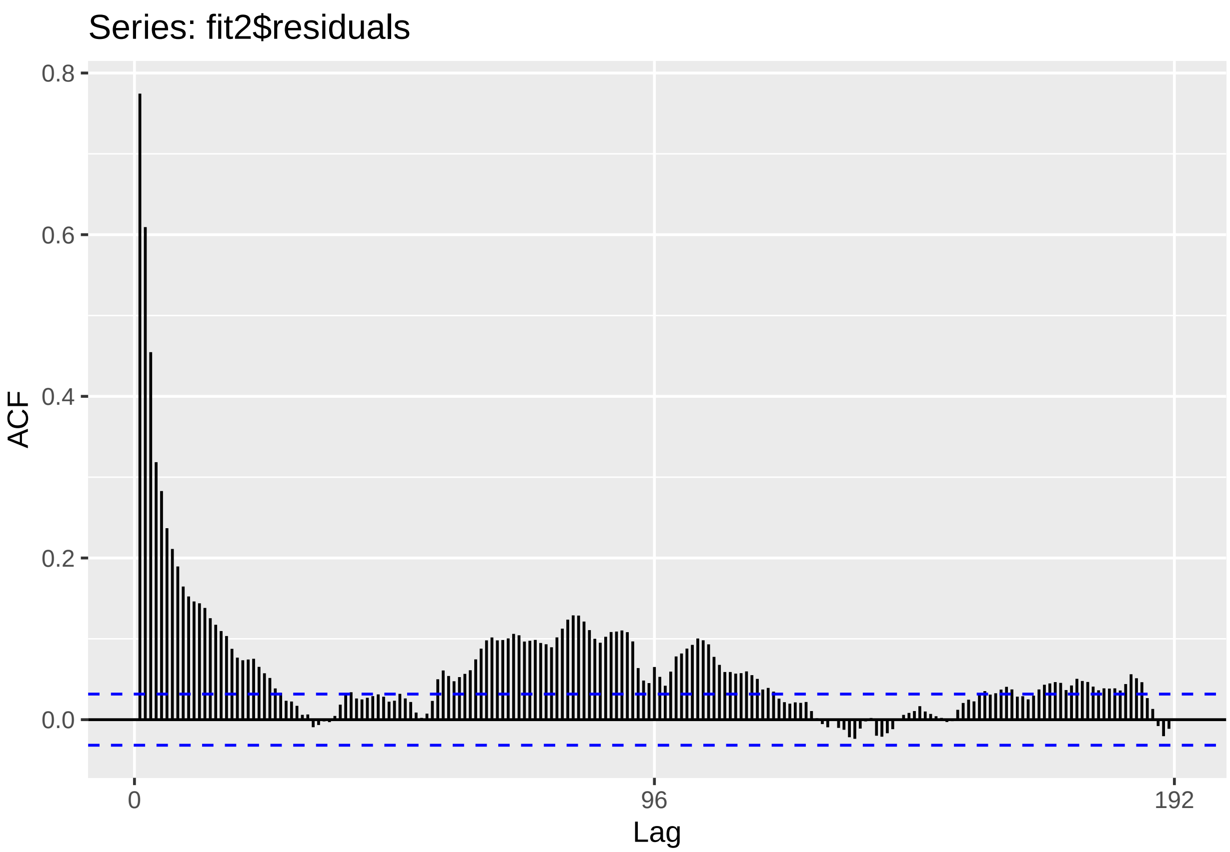
```r
checkresiduals(fit2, test=FALSE, plot=TRUE)
```



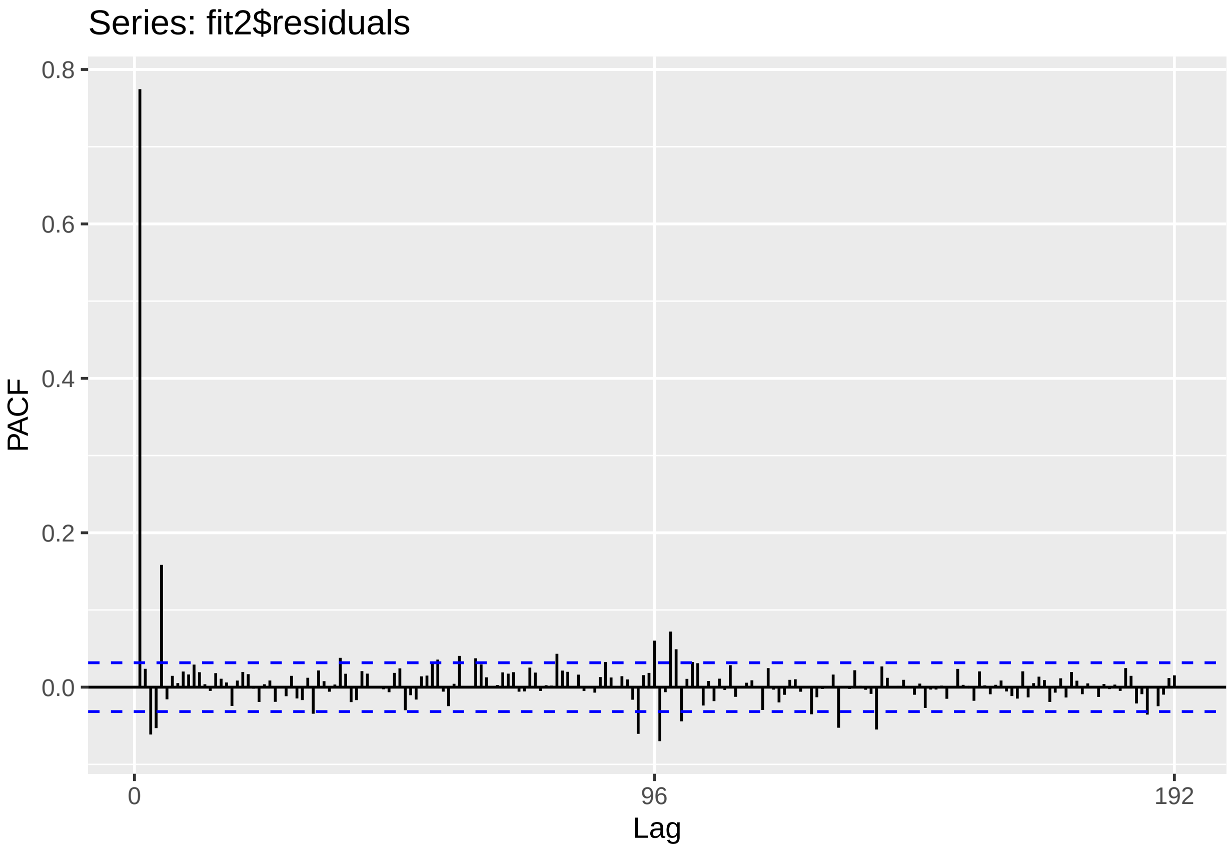

```r
checkresiduals(fit2, test='LB', plot=FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Linear regression model
## Q* = 8638.4, df = 192, p-value < 2.2e-16
##
## Model df: 0.   Total lags used: 192
```

```r
ggAcf(fit2$residuals)
```




```
ggPacf(fit2$residuals)
```



Les résidus ne sont pas indépendants. Il faudrait donc les extraire et obtenir une série stationnaire à l'aide d'une méthode de différenciation et de vérification des résidus.

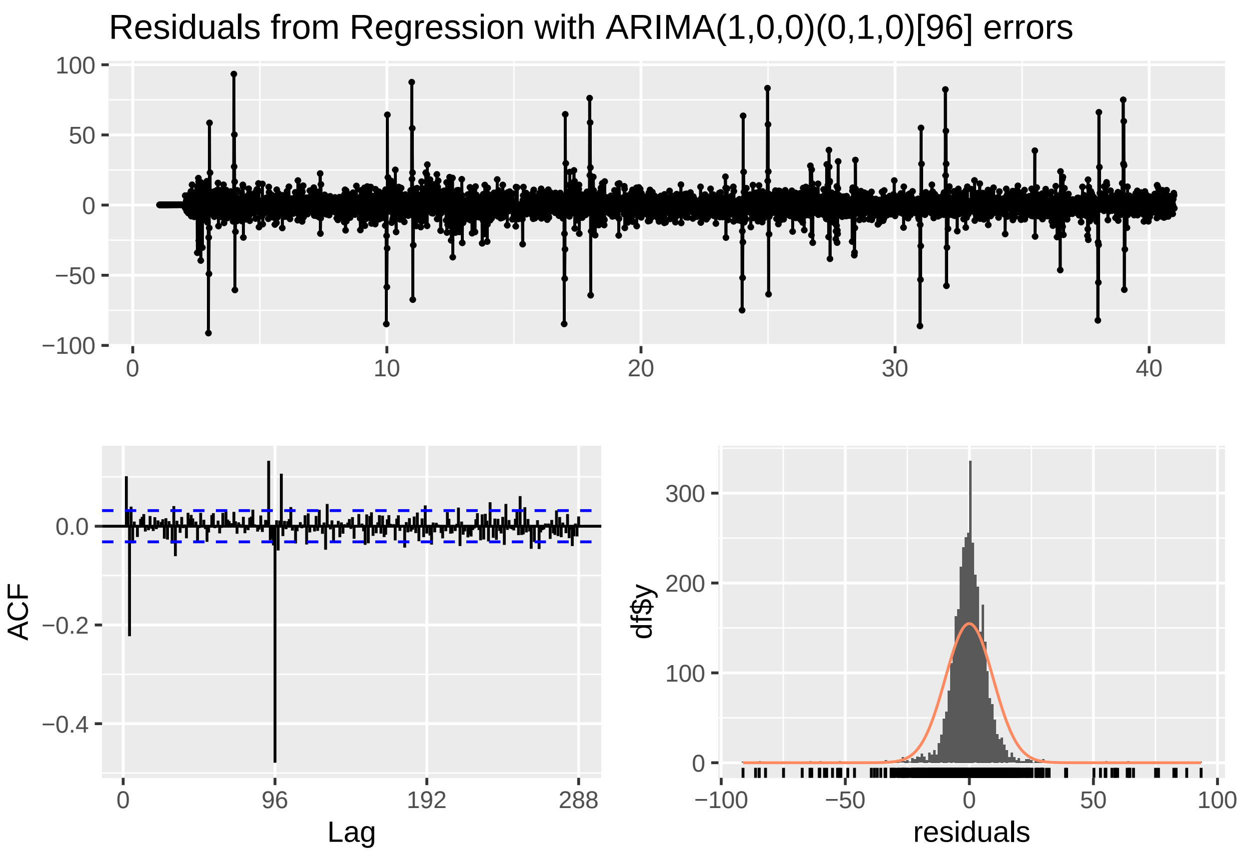
Modèle de régression dynamique quand résidus indépendants

```
fit3 = Arima(power_train, xreg=temperature_train, order=c(1, 0, 0), seasonal=c(0, 1, 0))
summary(fit3)
```

```
## Series: power_train
## Regression with ARIMA(1,0,0)(0,1,0)[96] errors
##
## Coefficients:
##          ar1    xreg
##       0.7798  0.3065
## s.e.  0.0103  0.2406
##
## sigma^2 = 95.55:  log likelihood = -13829.12
## AIC=27664.24   AICc=27664.24   BIC=27682.92
##
## Training set error measures:
##                       ME     RMSE      MAE        MPE     MAPE      MASE
## Training set -0.05764918 9.649274 5.619845 -0.1166433 2.610719 0.7128255
##                      ACF1
## Training set 0.0006469121
```

Check des résidus :

```r
checkresiduals(fit3, test=FALSE)
```




```r
checkresiduals(fit3, plot=FALSE)
```

```
##
##  Ljung-Box test
##
## data:  Residuals from Regression with ARIMA(1,0,0)(0,1,0)[96] errors
## Q* = 1522.2, df = 191, p-value < 2.2e-16
##
## Model df: 1.   Total lags used: 192
```

Réseaux de neurones

```r
fit4 = nnetar(power_train, xreg=temperature_train)
print(fit4)
```

```
## Series: power_train
## Model:  NNAR(20,1,12)[96]
## Call:   nnetar(y = power_train, xreg = temperature_train)
##
```

```
## Average of 20 networks, each of which is
## a 22-12-1 network with 289 weights
## options were - linear output units
##
## sigma^2 estimated as 46.16
```

```r
autoplot(forecast(train))
```