Prova Prática

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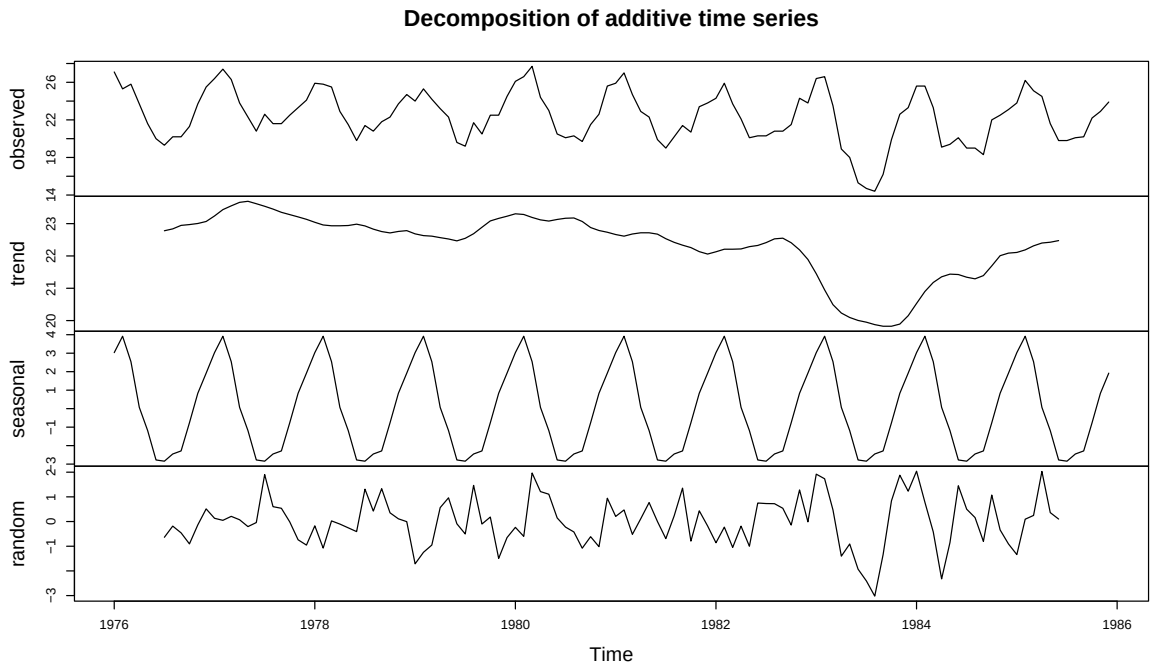
```
library(ggplot2)
library(tseries)
library(readODS)
library(tidyverse)
library(readxl)
```

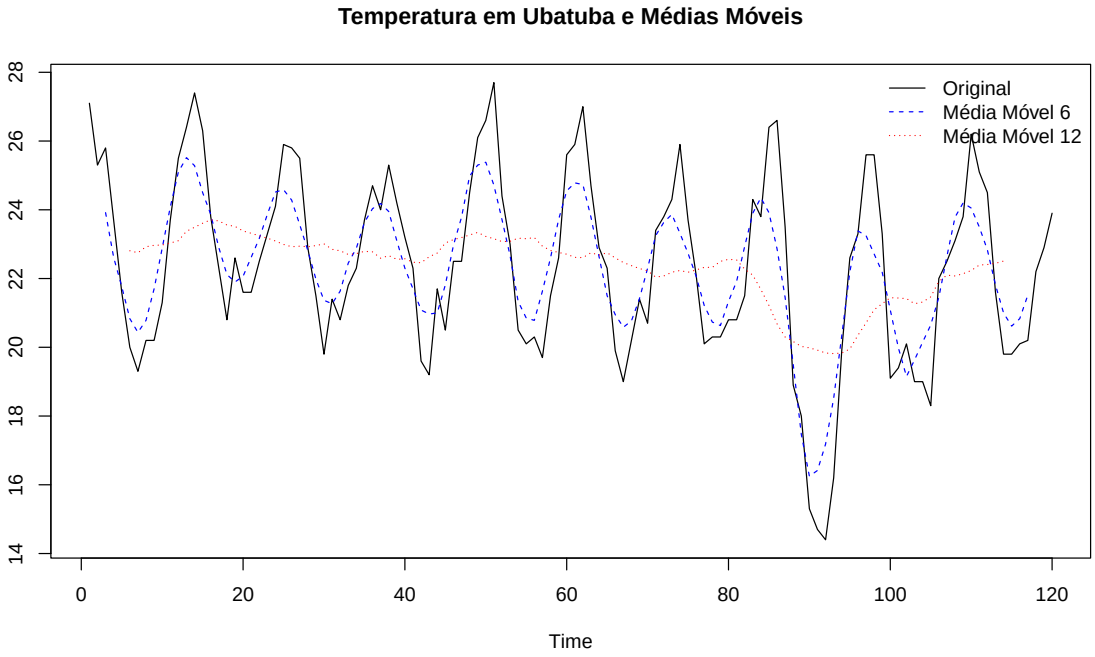
A série Temperatura em Ubatuba:

```
data <- read_ods("data/temperatura.ods")

# transformando em formato time series

data_ts <- ts(data$Ubatuba,  start = c(1976, 1), frequency = 12)

decompose <- decompose(data_ts)

plot(decompose)
```



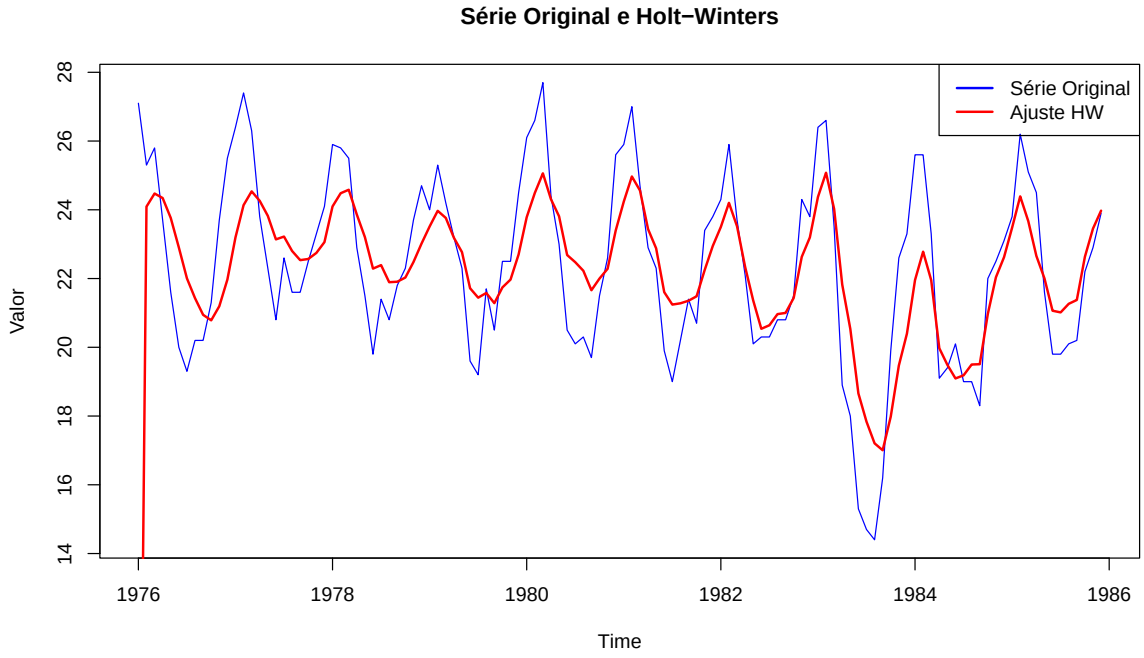

```r
data_fit <- data %>% select(-c(Cananeia))

# suavização por médias móveis

ma <- function(x, order) {
  if (!is.numeric(x)) stop("x must be numeric")
  if (!is.numeric(order) || order <= 0) stop("order must be a positive integer")

  filt <- rep(1/order, order)  # Criando o filtro de médias móveis
  ma_values <- stats::filter(x, filt, sides = 2)  # Aplicando a média móvel com a função n

  return(ma_values)
}


ma_6 <- ma(data_fit$Ubatuba, order = 6)
ma_12 <- ma(data_fit$Ubatuba, order = 12)

df_ma <- cbind(data_fit$Ubatuba,
               ma_6,
```

```
              ma_12)


ts.plot(df_ma, col = c("black", "blue", "red"), lty = 1:3,
        main = "Temperatura em Ubatuba e Médias Móveis")
legend("topright",
       legend = c("Original",
                  "Média Móvel 6",
                  "Média Móvel 12"),
       col = c("black", "blue", "red"),
       lty = 1:3, bty = "n")
```




```
# ajustar o modelo de holt-winters
hw <- function(x, seasonal = "additive", alpha = NULL, beta = NULL, gamma = NULL) {
  if (!is.ts(x)) stop("x must be a time series object")
  if (!seasonal %in% c("additive", "multiplicative")) stop("Invalid seasonal argument")
  if (length(x) < 2 * frequency(x)) stop("Time series too short for Holt-Winters method")

  n <- length(x)
  freq <- frequency(x)
```

```r
  l <- mean(head(x, freq))  # Inicialização do nível
  b <- (mean(tail(x, freq)) - mean(head(x, freq))) / freq  # Inicialização da tendência
  s <- rep(1, freq)  # Inicialização da sazonalidade

  if (is.null(alpha)) alpha <- 0.2
  if (is.null(beta)) beta <- 0.1
  if (is.null(gamma)) gamma <- 0.1

  forecast <- numeric(n)
  for (t in 2:n) {
    if (t > freq) {
      if (seasonal == "additive") {
        s[t %% freq + 1] <- gamma * (x[t] - l) + (1 - gamma) * s[t %% freq + 1]
      } else {
        s[t %% freq + 1] <- gamma * (x[t] / l) + (1 - gamma) * s[t %% freq + 1]
      }
    }

    l_new <- alpha * (x[t] - s[t %% freq + 1]) + (1 - alpha) * (l + b)
    b <- beta * (l_new - l) + (1 - beta) * b
    l <- l_new
    forecast[t] <- l + b + ifelse(seasonal == "additive", s[t %% freq + 1], l * s[t %% fre
  }

  fitted_ts <- ts(forecast, start = start(x), frequency = frequency(x))

  return(list(level = l, trend = b, seasonal = s, fitted = fitted_ts))
}

modelo_hw <- hw(data_ts, seasonal = "additive")

plot(data_ts, type = "l", col = "blue",
     main = "Série Original e Holt-Winters",
     ylab = "Valor")
lines(modelo_hw$fitted, col = "red",
      lwd = 2)
legend("topright",
       legend = c("Série Original", "Ajuste HW"),
       col = c("blue", "red"), lwd = 2)
```



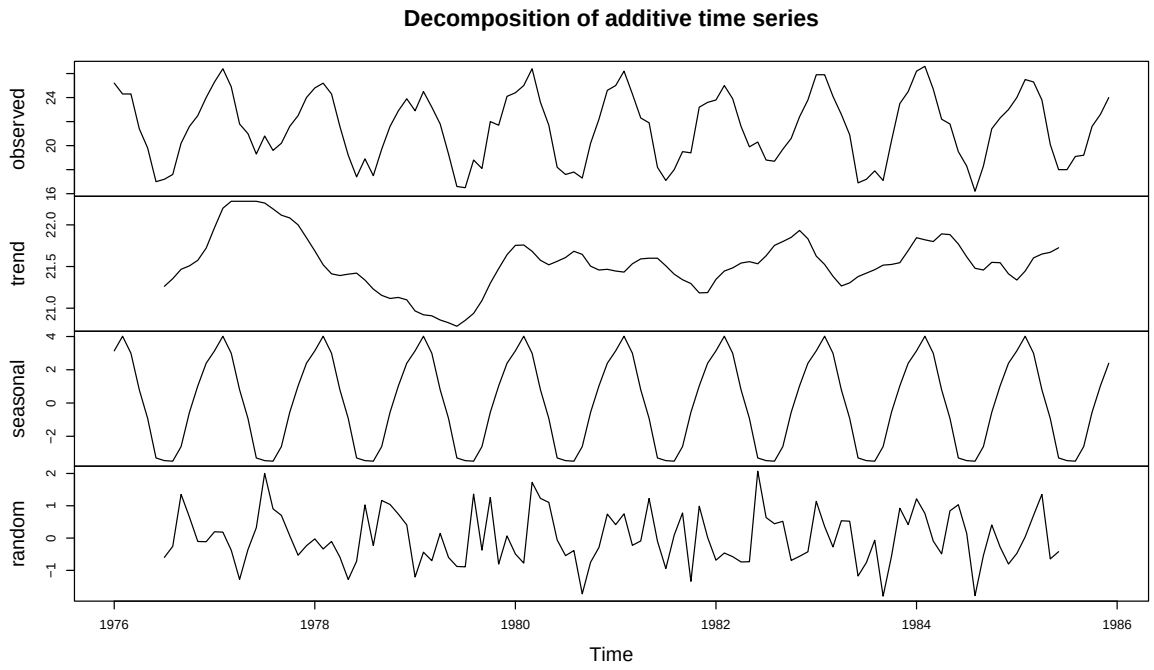

```r
# Comparando suavizações

# Cálculo das métricas de erro
mae <- function(real, previsto) mean(abs(real - previsto), na.rm = TRUE)
mse <- function(real, previsto) mean((real - previsto)^2, na.rm = TRUE)
mape <- function(real, previsto) mean(abs((real - previsto) / real), na.rm = TRUE) * 100


# Criando um dataframe para comparação
df_comparacao <- data.frame(
  Data = time(data_ts),
  Original = as.numeric(data_ts),
  HoltWinters = as.numeric(modelo_hw$fitted),
  MediaMovel6 = as.numeric(ma_6),
  MediaMovel12 = as.numeric(ma_12)
)

resultados_erro <- data.frame(
  Metodo = c("Holt-Winters", "Média Móvel 6", "Média Móvel 12"),
  MAE = c(mae(df_comparacao$Original, df_comparacao$HoltWinters),
```

```
          mae(df_comparacao$Original, df_comparacao$MediaMovel6),
          mae(df_comparacao$Original, df_comparacao$MediaMovel12)),
  MSE = c(mse(df_comparacao$Original, df_comparacao$HoltWinters),
          mse(df_comparacao$Original, df_comparacao$MediaMovel6),
          mse(df_comparacao$Original, df_comparacao$MediaMovel12)),
  MAPE = c(mape(df_comparacao$Original, df_comparacao$HoltWinters),
           mape(df_comparacao$Original, df_comparacao$MediaMovel6),
           mape(df_comparacao$Original, df_comparacao$MediaMovel12))
)

print(resultados_erro)
```

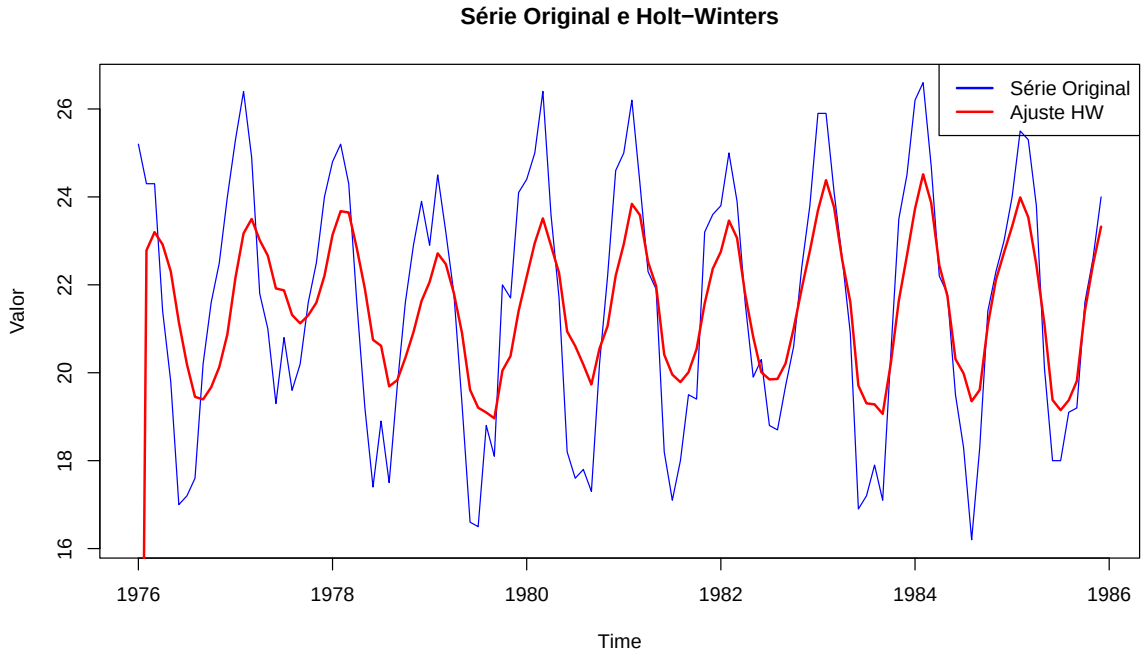
```
          Metodo      MAE      MSE     MAPE
1   Holt-Winters 1.515253 8.666084 6.740672
2  Média Móvel 6 1.034058 1.609114 4.706469
3 Média Móvel 12 2.144037 6.339873 9.868902
```

A série temperatura em Cananeia:

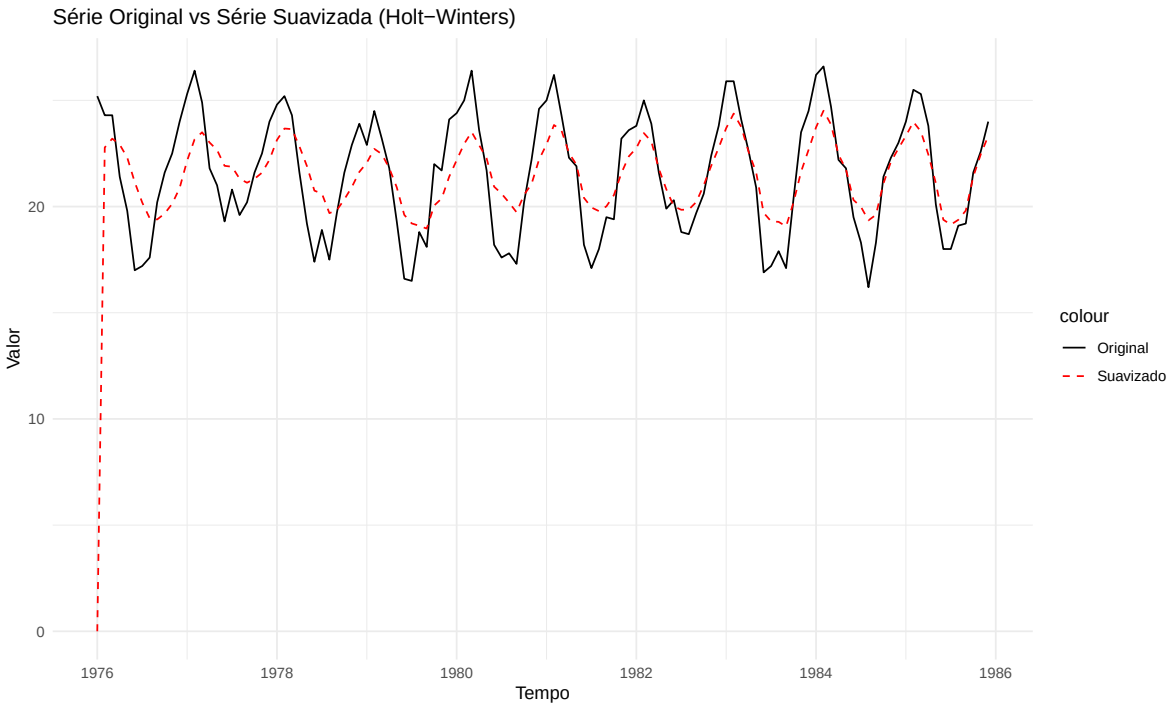
```
data <- read_ods("data/temperatura.ods")

# transformando em formato time series

data_ts <- ts(data$Cananeia,  start = c(1976, 1), frequency = 12)


decompose <- decompose(data_ts)

plot(decompose)
```



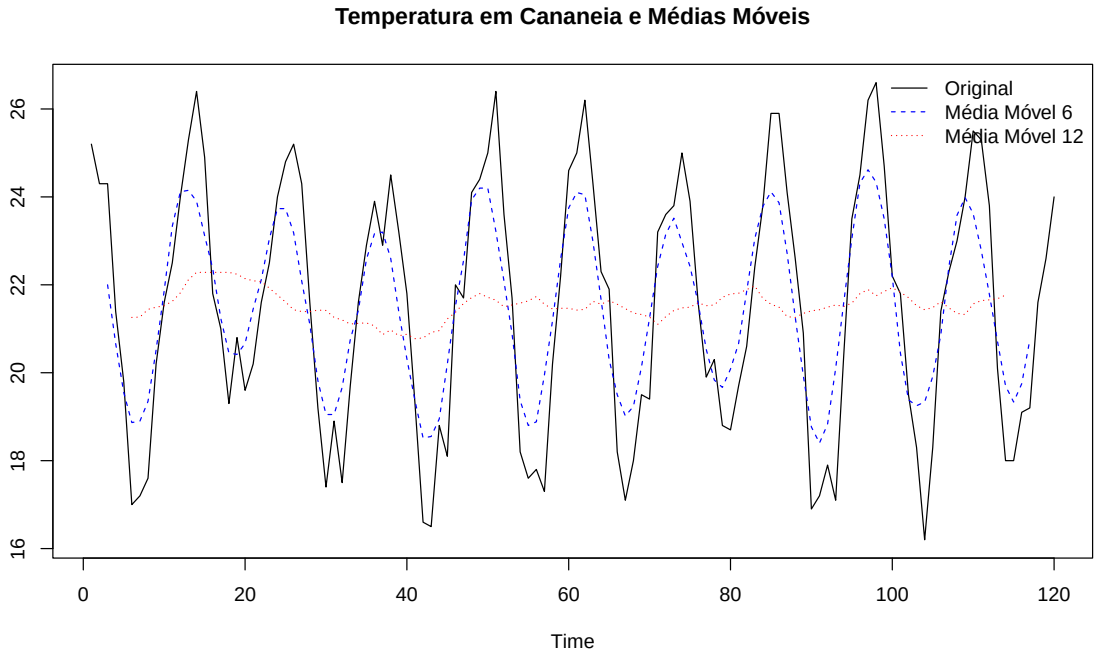

```r
data_fit <- data %>% select(-c(Ubatuba))

# ajustar o modelo de holt-winters
modelo_hw <- hw(data_ts, seasonal = "additive")

plot(data_ts, type = "l", col = "blue",
     main = "Série Original e Holt-Winters",
     ylab = "Valor")
lines(modelo_hw$fitted, col = "red",
      lwd = 2)
legend("topright", legend = c("Série Original", "Ajuste HW"), col = c("blue", "red"), lwd
```




```r
# criando um dataframe para visualização
df_plot <- data.frame(
  Data = time(data_ts),
  Original = as.numeric(data_ts),
  Suavizado = as.numeric(modelo_hw$fitted)
)

# plotando com ggplot2
ggplot(df_plot, aes(x = Data)) +
  geom_line(aes(y = Original, color = "Original")) +
  geom_line(aes(y = Suavizado, color = "Suavizado"),
            linetype = "dashed") +
  labs(title = "Série Original vs Série Suavizada (Holt-Winters)",
       x = "Tempo", y = "Valor") +
  scale_color_manual(values = c("Original" = "black",
                                "Suavizado" = "red")) +
  theme_minimal()
```




```
# suavização por médias móveis

ma_6 <- ma(data_fit$Cananeia, order = 6)
ma_12 <- ma(data_fit$Cananeia, order = 12)

df_ma <- cbind(data_fit$Cananeia,
               ma_6,
               ma_12)


ts.plot(df_ma, col = c("black", "blue", "red"),
        lty = 1:3,
        main = "Temperatura em Cananeia e Médias Móveis")
legend("topright",
       legend = c("Original", "Média Móvel 6", "Média Móvel 12"),
       col = c("black", "blue", "red"),
       lty = 1:3, bty = "n")
```



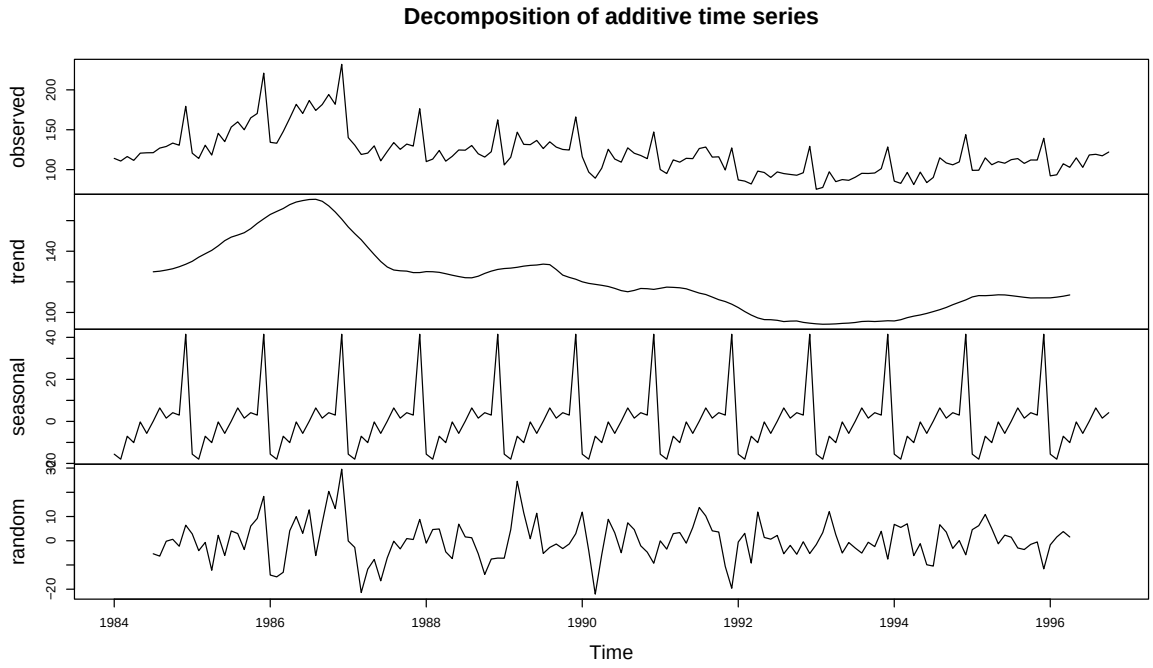

```
# comparando suavizações

# Criando um dataframe para comparação
df_comparacao <- data.frame(
  Data = time(data_ts),
  Original = as.numeric(data_ts),
  HoltWinters = as.numeric(modelo_hw$fitted),
  MediaMovel6 = as.numeric(ma_6),
  MediaMovel12 = as.numeric(ma_12)
)

resultados_erro <- data.frame(
  Metodo = c("Holt-Winters", "Média Móvel 6", "Média Móvel 12"),
  MAE = c(mae(df_comparacao$Original, df_comparacao$HoltWinters),
          mae(df_comparacao$Original, df_comparacao$MediaMovel6),
          mae(df_comparacao$Original, df_comparacao$MediaMovel12)),
  MSE = c(mse(df_comparacao$Original, df_comparacao$HoltWinters),
          mse(df_comparacao$Original, df_comparacao$MediaMovel6),
          mse(df_comparacao$Original, df_comparacao$MediaMovel12)),
  MAPE = c(mape(df_comparacao$Original, df_comparacao$HoltWinters),
```

```
            mape(df_comparacao$Original, df_comparacao$MediaMovel6),
            mape(df_comparacao$Original, df_comparacao$MediaMovel12))
)

print(resultados_erro)
```

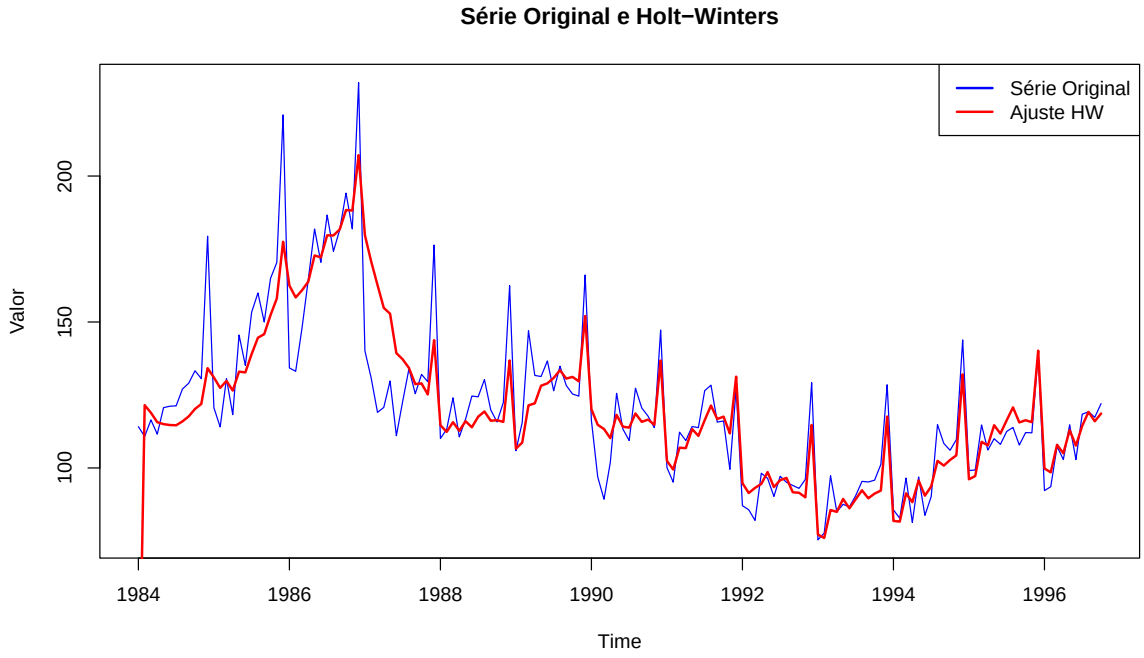
```
          Metodo      MAE      MSE      MAPE
1   Holt-Winters 1.647792 8.227527  7.762889
2  Média Móvel 6 1.123768 1.831444  5.401060
3 Média Móvel 12 2.450000 7.885818 11.784360
```

Série Consumo

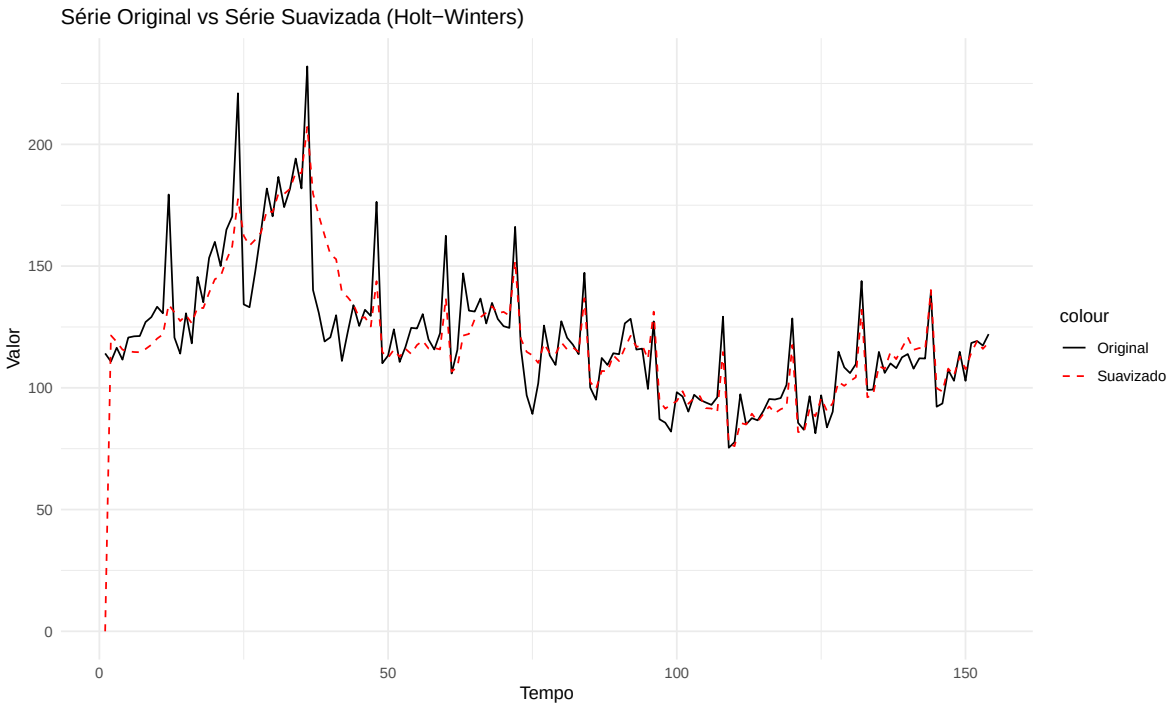
```
data <- read_excel("data/CONSUMO.xls")

# transformando em formato time series

data_ts <- ts(data$consumo,  start = c(1984,1), frequency = 12)


decompose <- decompose(data_ts)

plot(decompose)
```



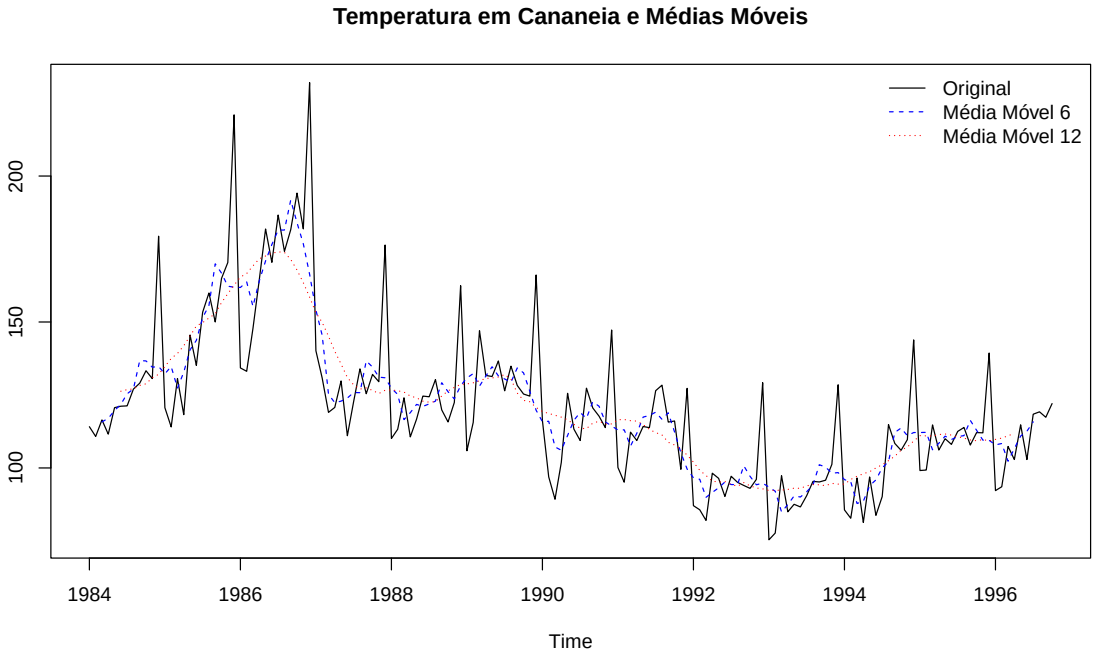

```r
# ajustar o modelo de holt-winters
modelo_hw <- hw(data_ts, seasonal = "additive")

plot(data_ts, type = "l", col = "blue", main = "Série Original e Holt-Winters", ylab = "Va
lines(modelo_hw$fitted, col = "red", lwd = 2)
legend("topright", legend = c("Série Original", "Ajuste HW"), col = c("blue", "red"), lwd
```




```r
# criando um dataframe para visualização
df_plot <- data.frame(
  Data = time(data$data),
  Original = as.numeric(data$consumo),
  Suavizado = as.numeric(modelo_hw$fitted)
)

# plotando com ggplot2
ggplot(df_plot, aes(x = Data)) +
  geom_line(aes(y = Original, color = "Original")) +
  geom_line(aes(y = Suavizado, color = "Suavizado"), linetype = "dashed") +
  labs(title = "Série Original vs Série Suavizada (Holt-Winters)",
       x = "Tempo", y = "Valor") +
  scale_color_manual(values = c("Original" = "black", "Suavizado" = "red")) +
  theme_minimal()
```




```r
# suavização por médias móveis

ma_6 <- ma(data_ts, order = 6)
ma_12 <- ma(data_ts, order = 12)

df_ma <- cbind(data$consumo,
               ma_6,
               ma_12)


ts.plot(df_ma, col = c("black", "blue", "red"), lty = 1:3,
        main = "Temperatura em Cananeia e Médias Móveis")
legend("topright",
       legend = c("Original", "Média Móvel 6", "Média Móvel 12"),
       col = c("black", "blue", "red"), lty = 1:3, bty = "n")
```




```
# comparando suavizações

# Criando um dataframe para comparação
df_comparacao <- data.frame(
  Data = time(data$data),
  Original = as.numeric(data$consumo),
  HoltWinters = as.numeric(modelo_hw$fitted),
  MediaMovel6 = as.numeric(ma_6),
  MediaMovel12 = as.numeric(ma_12)
)

resultados_erro <- data.frame(
  Metodo = c("Holt-Winters", "Média Móvel 6", "Média Móvel 12"),
  MAE = c(mae(df_comparacao$Original, df_comparacao$HoltWinters),
          mae(df_comparacao$Original, df_comparacao$MediaMovel6),
          mae(df_comparacao$Original, df_comparacao$MediaMovel12)),
  MSE = c(mse(df_comparacao$Original, df_comparacao$HoltWinters),
          mse(df_comparacao$Original, df_comparacao$MediaMovel6),
          mse(df_comparacao$Original, df_comparacao$MediaMovel12)),
  MAPE = c(mape(df_comparacao$Original, df_comparacao$HoltWinters),
```

```
            mape(df_comparacao$Original, df_comparacao$MediaMovel6),
            mape(df_comparacao$Original, df_comparacao$MediaMovel12))
)

print(resultados_erro)
```

```
          Metodo       MAE      MSE     MAPE
1   Holt-Winters  8.825851 234.1469 7.044512
2  Média Móvel 6  9.955951 221.8638 7.980290
3 Média Móvel 12 11.331917 278.5654 9.086068
```