第二次练习课参考答案

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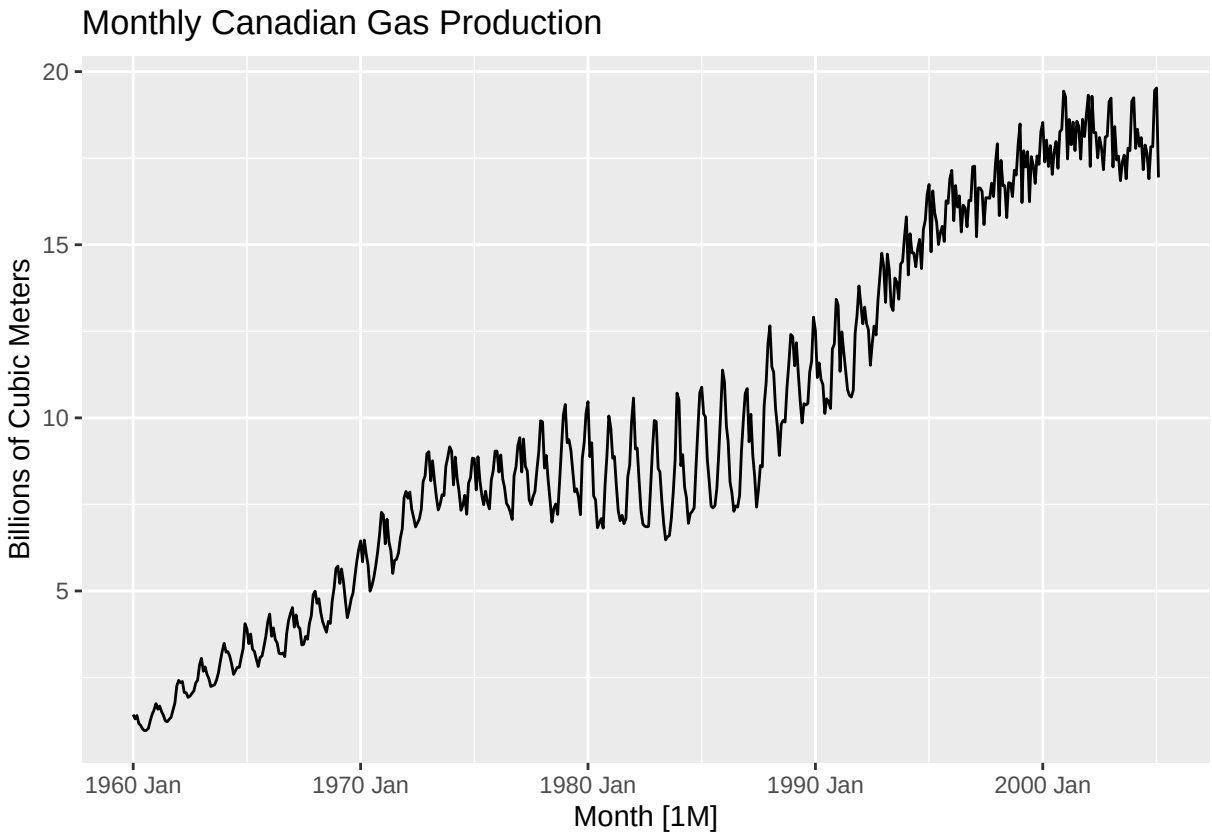
首先调用程序包（已隐去调用后显示信息）

```
library(fpp3)
library(patchwork)
library(seasonal)
```

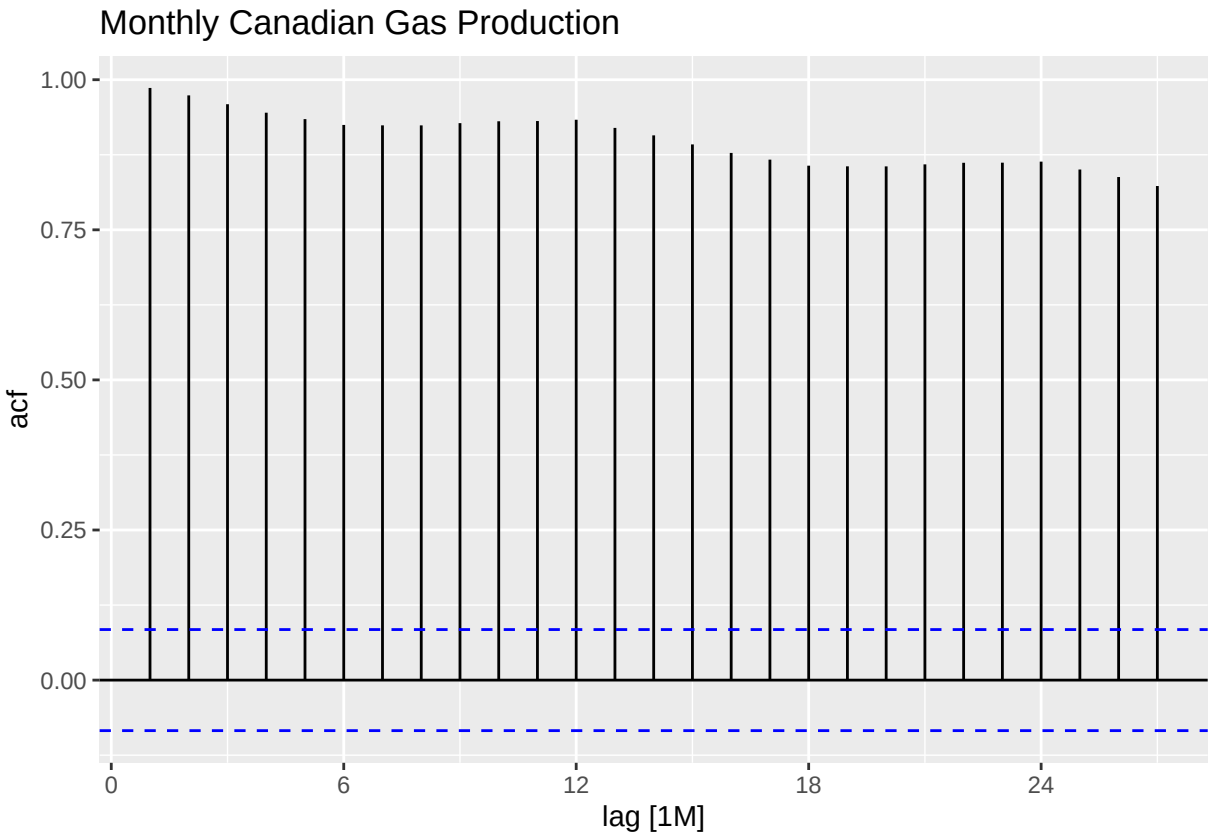
1. 绘制天然气产量的时序图。

```
autoplot(canadian_gas, Volume) +
  labs(
    title = "Monthly Canadian Gas Production",
    y = "Billions of Cubic Meters"
  )
```



2. 绘制自相关图，判断该序列是否存在趋势和季节性，并说明理由。

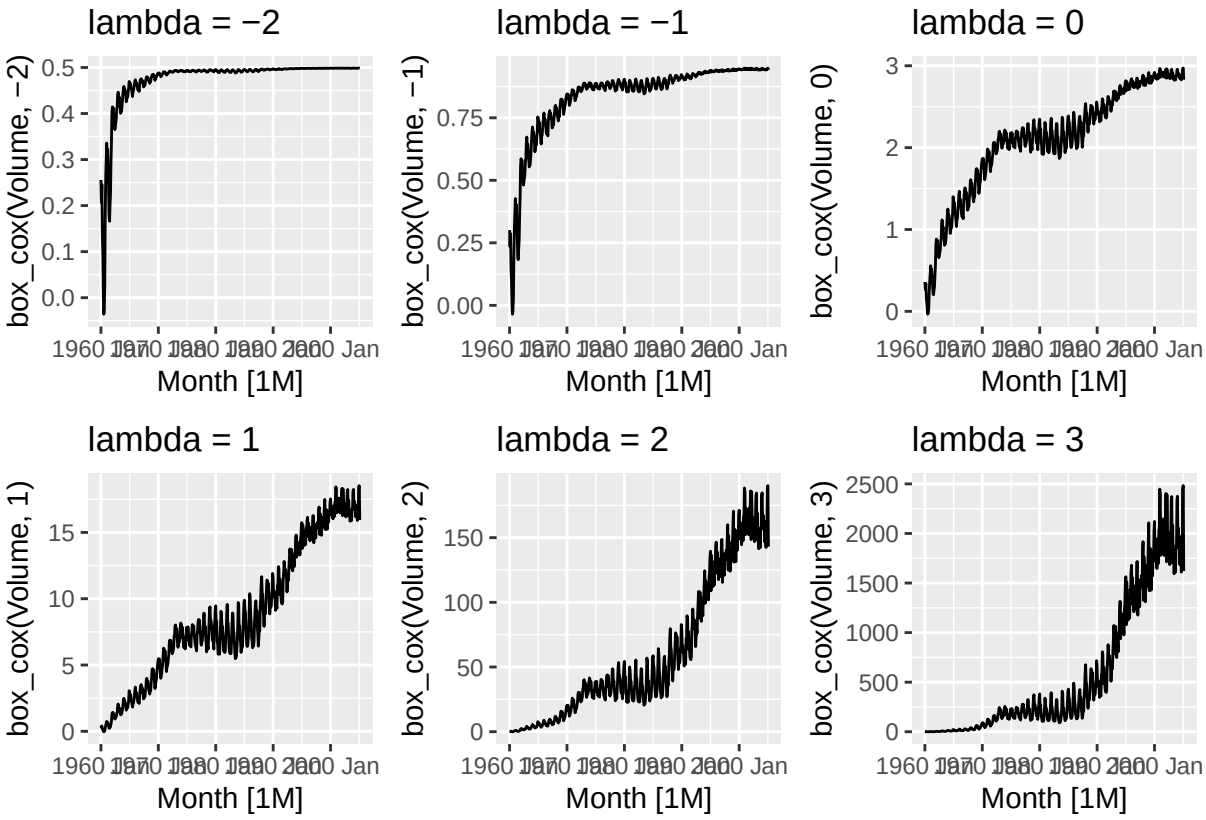
```
canadian_gas |>
  ACF(Volume) |>
  autoplot() +
  labs(
    title = "Monthly Canadian Gas Production"
  )
```



自相关系数随着滞后期数的增加而递减，提示存在趋势。滞后 12 和 24 期的自相关系数稍高于附近的其他滞后期，提示存在周期为 12 期的季节性。

3. 在不使用 Guerrero 法的情况下，尝试用不同的 λ 值进行 Box-Cox 变换，结合结果判断 Box-Cox 变换是否适用于此序列。

```
p1 <- canadian_gas |> autoplot(box_cox(Volume,-2)) + labs(title = "lambda = -2")
p2 <- canadian_gas |> autoplot(box_cox(Volume,-1)) + labs(title = "lambda = -1")
p3 <- canadian_gas |> autoplot(box_cox(Volume,0)) + labs(title = "lambda = 0")
p4 <- canadian_gas |> autoplot(box_cox(Volume,1)) + labs(title = "lambda = 1")
p5 <- canadian_gas |> autoplot(box_cox(Volume,2)) + labs(title = "lambda = 2")
p6 <- canadian_gas |> autoplot(box_cox(Volume,3)) + labs(title = "lambda = 3")
p1 + p2 + p3 + p4 + p5 + p6
```



首先注意当 $\lambda = 1$ 时，Box-Cox 变换仅将原序列在垂直方向向下移动一个单位。这里选取了 $\lambda = -2, -1, 0, 1, 2, 3$ 六个值进行比较。从图中可以看出，这六个参数值都无法将原序列的季节性波动调整到同一水平上，这是因为原序列中季节性波动幅度并不是随着时间推移而单调增加或减少的。因此可以判断 Box-Cox 变换并不适用于此序列。

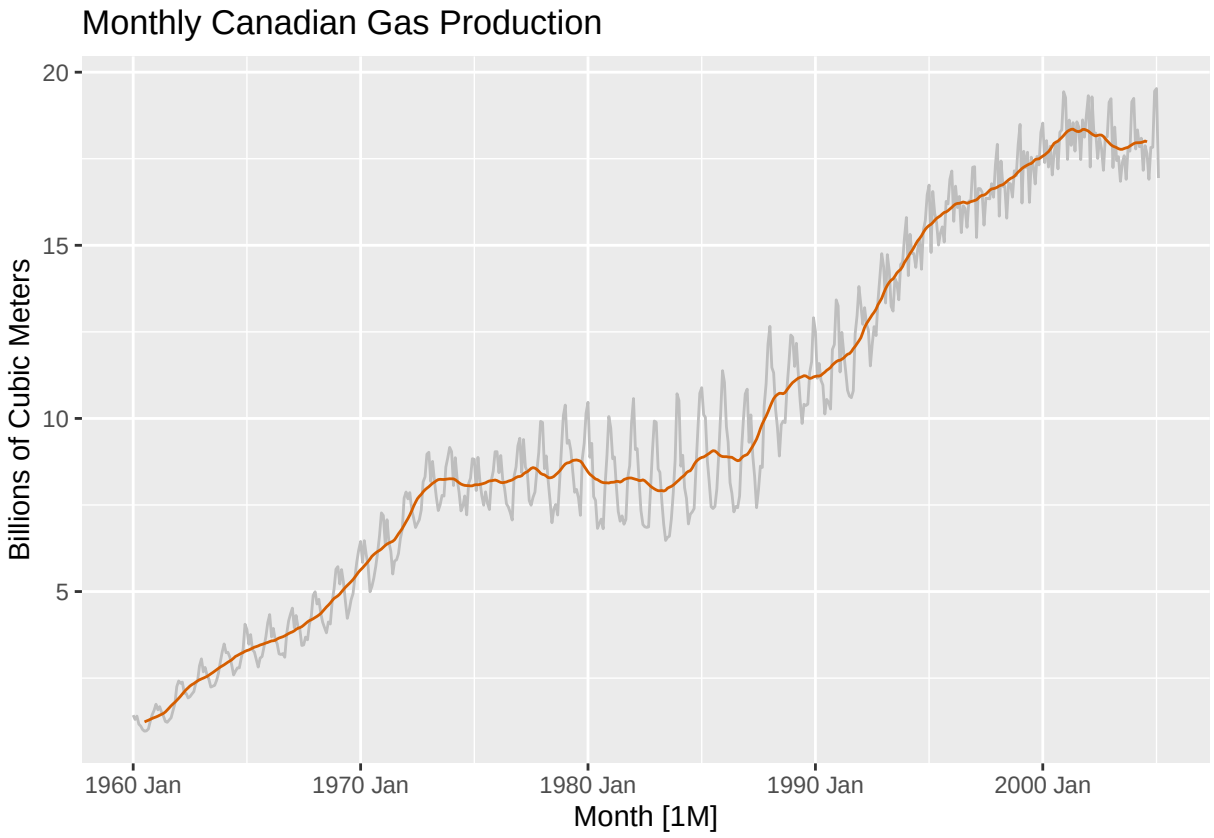
4. 考虑对天然气产量序列进行成分分解，并回答下列问题：

i. 用移动平均法估计趋势项，并将原序列和趋势项的估计值绘制在同一个时序图中。写出你用的移动平均模型。

```
cgas_ma <- canadian_gas |>
  mutate(
    `12-MA` = slider::slide_dbl(Volume, mean,
                                .before = 5, .after = 6,
                                .complete = TRUE),
    `2x12-MA` = slider::slide_dbl(`12-MA`, mean,
                                  .before = 1, .after = 0,
                                  .complete = TRUE)
  )
cgas_ma |>
  autoplot(Volume, colour = "gray") +
  geom_line(aes(y = `2x12-MA`), colour = "#D55E00") +
```

```
  labs(
    title = "Monthly Canadian Gas Production",
    y = "Billions of Cubic Meters"
  )
```

```
## Warning: Removed 12 rows containing missing values or values outside the scale range
## (`geom_line()`).
```



根据第 2 问的分析结果，假设季节性周期为 12，因此采用 2×12-MA。代码中的 12-MA 选择了向过去取 5 期、向未来取 6 期的模型，因此后面的 2-MA 就选择了向过去取 1 期、项未来取 0 期的模型。数学表达式为

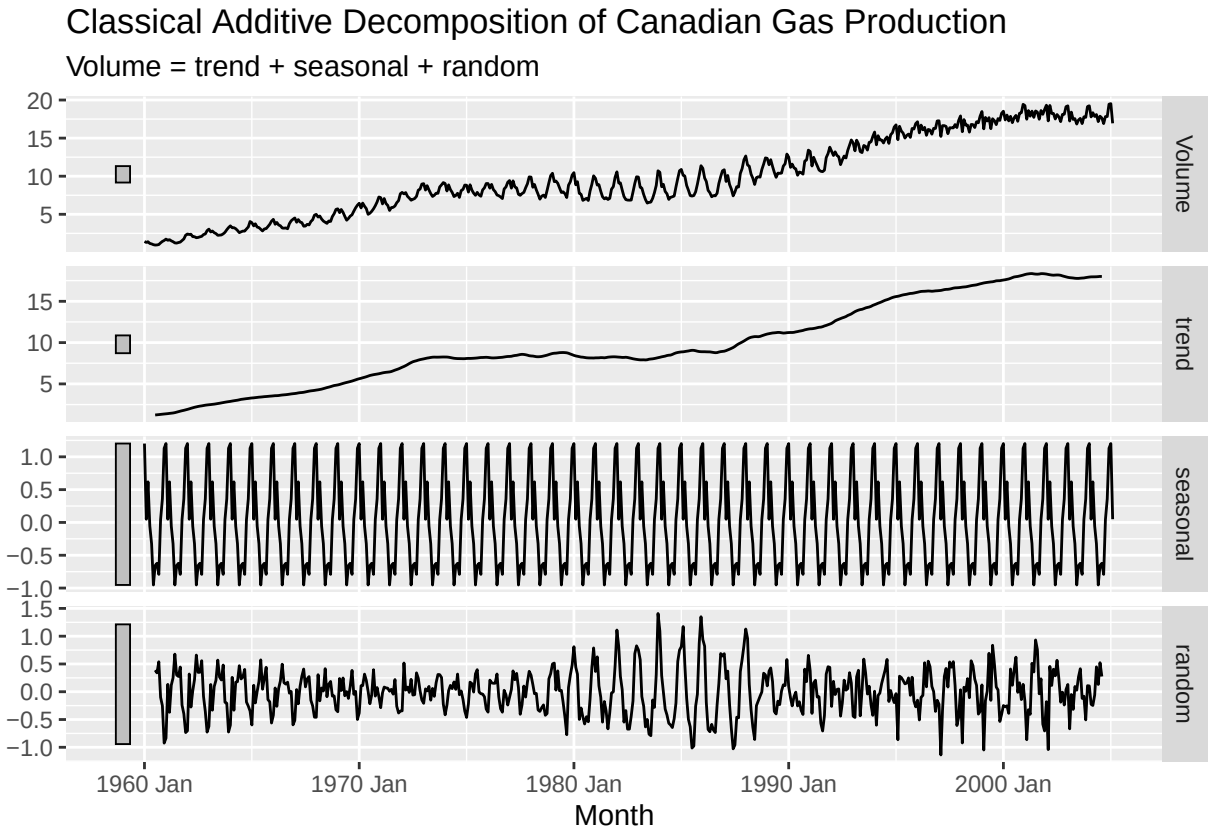
$$\hat{T}_t = \frac{1}{2} \sum_{r=-1}^{0} \left(\frac{1}{12} \sum_{j=-5}^{6} y_{t+j+r} \right)$$

ii. 分别用传统分解法（加法模型和乘法模型）、X-11、SEATS、STL 法进行成分分解并绘图。比较各种方法的分解结果，并描述它们的区别。

```
# 传统分解法加法模型
cgas_dclassic_add <- canadian_gas |>
  model(
    classical_decomposition(Volume, type = "additive")
  ) |>
  components()
```

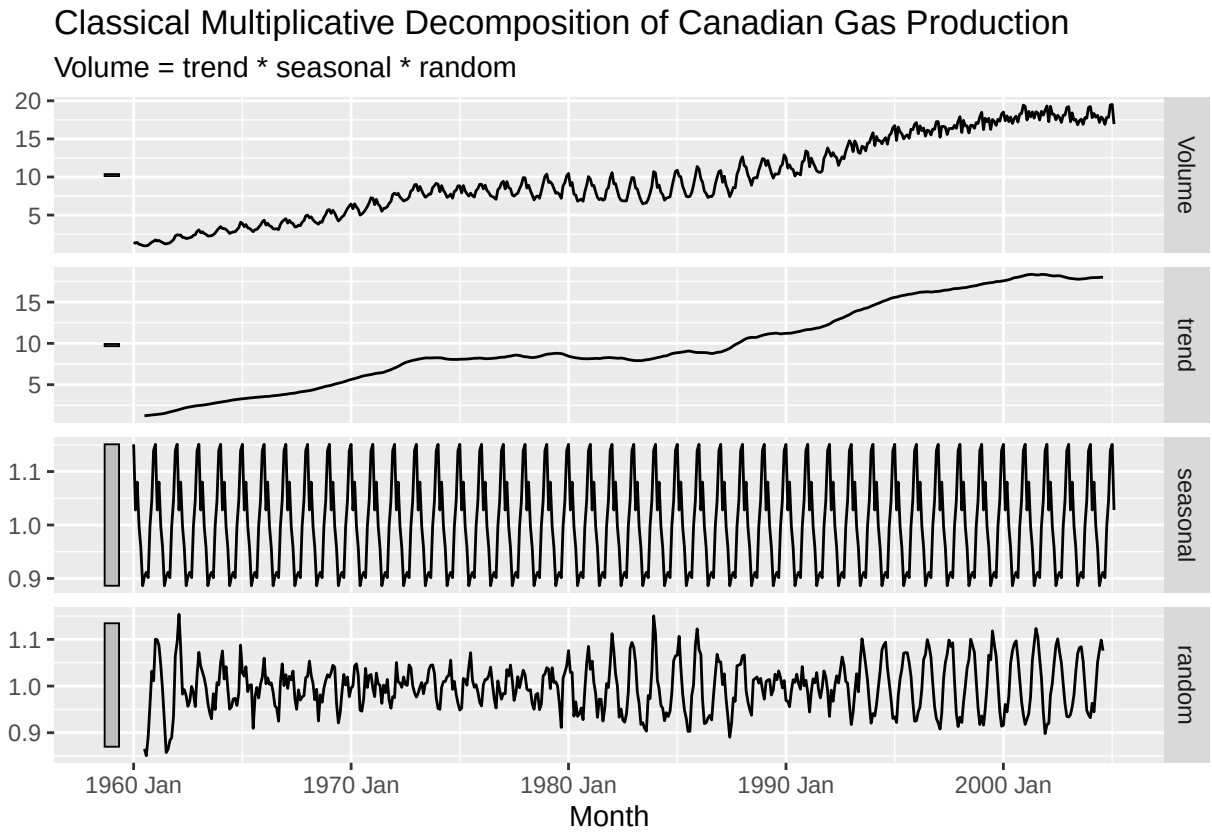
```
cgas_dclassic_add |>
  autoplot() +
  labs(
    title = "Classical Additive Decomposition of Canadian Gas Production"
  )
```

```
## Warning: Removed 6 rows containing missing values or values outside the scale range
## (`geom_line()`).
```

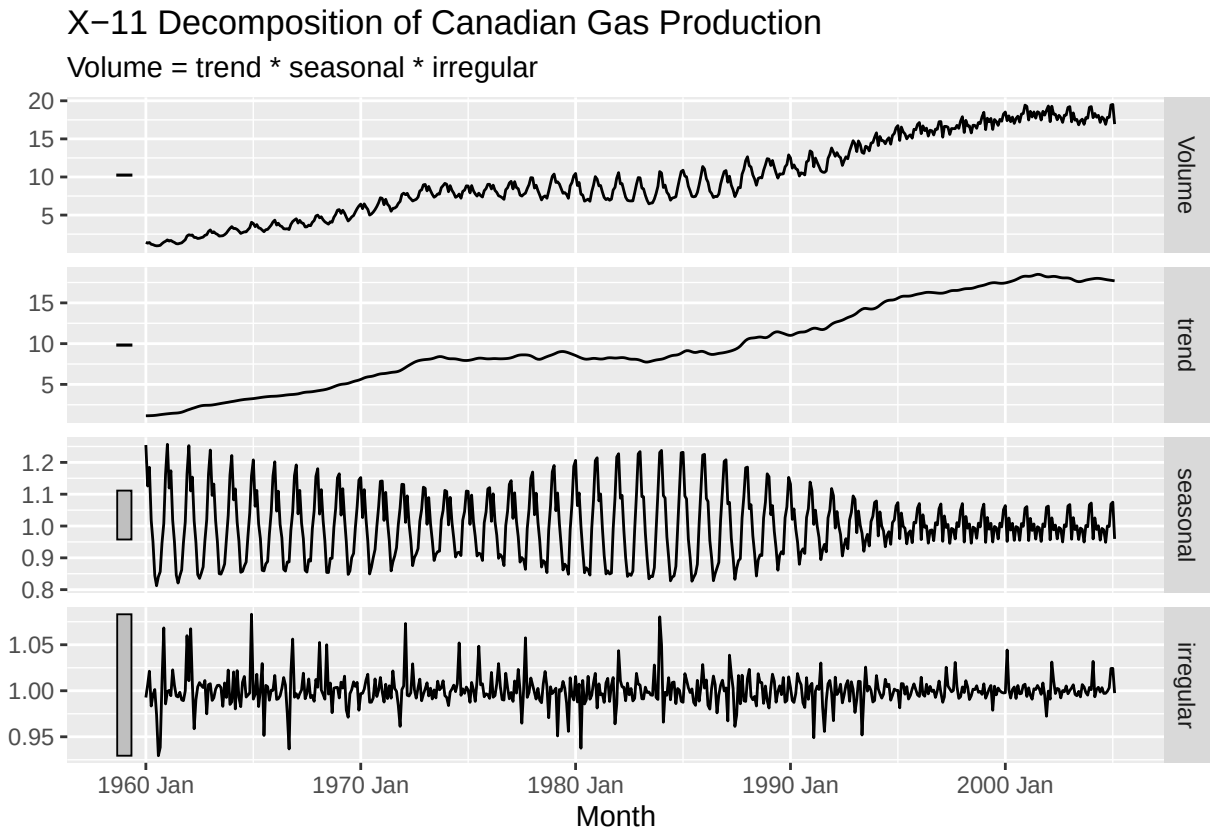



```
# 传统分解法乘法模型
cgas_dclassic_multi <- canadian_gas |>
  model(
    classical_decomposition(Volume, type = "multiplicative")
  ) |>
  components()
cgas_dclassic_multi |>
  autoplot() +
  labs(
    title = "Classical Multiplicative Decomposition of Canadian Gas Production"
  )
```

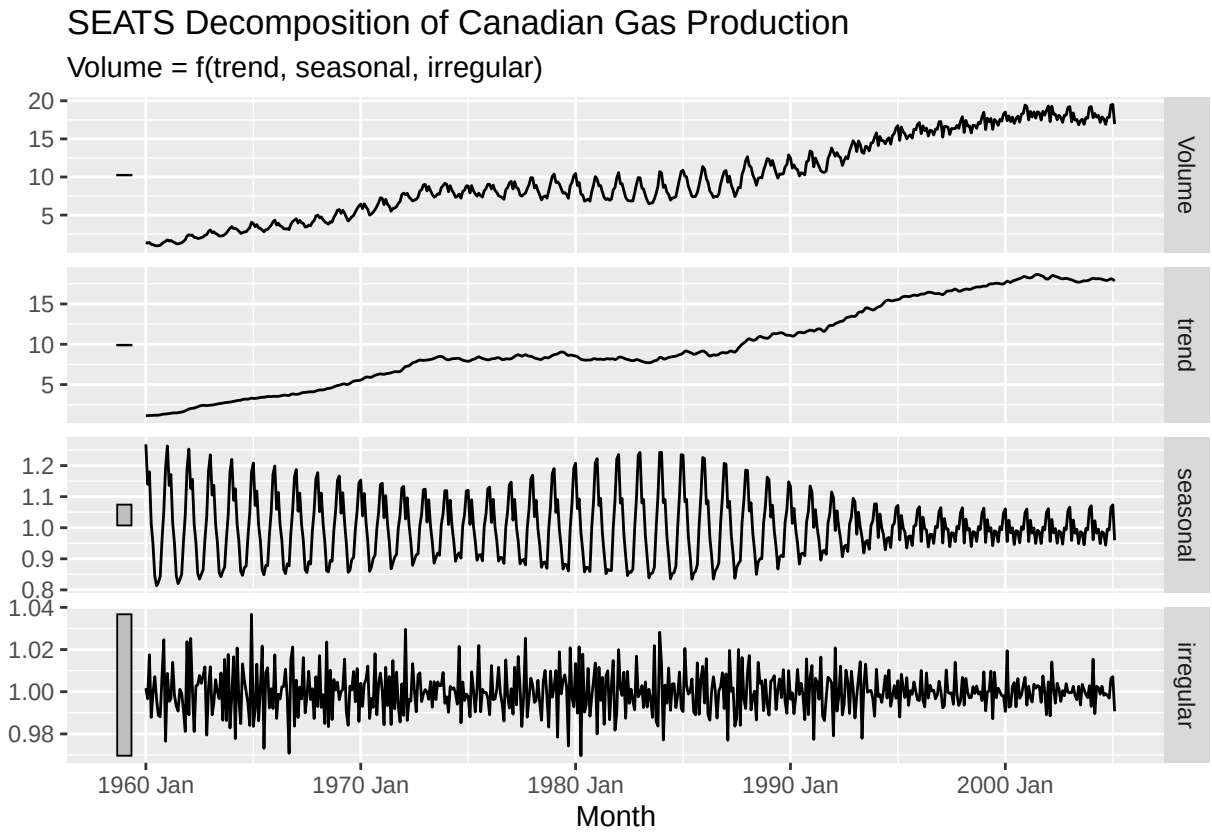
```
## Warning: Removed 6 rows containing missing values or values outside the scale range
## (`geom_line()`).
```



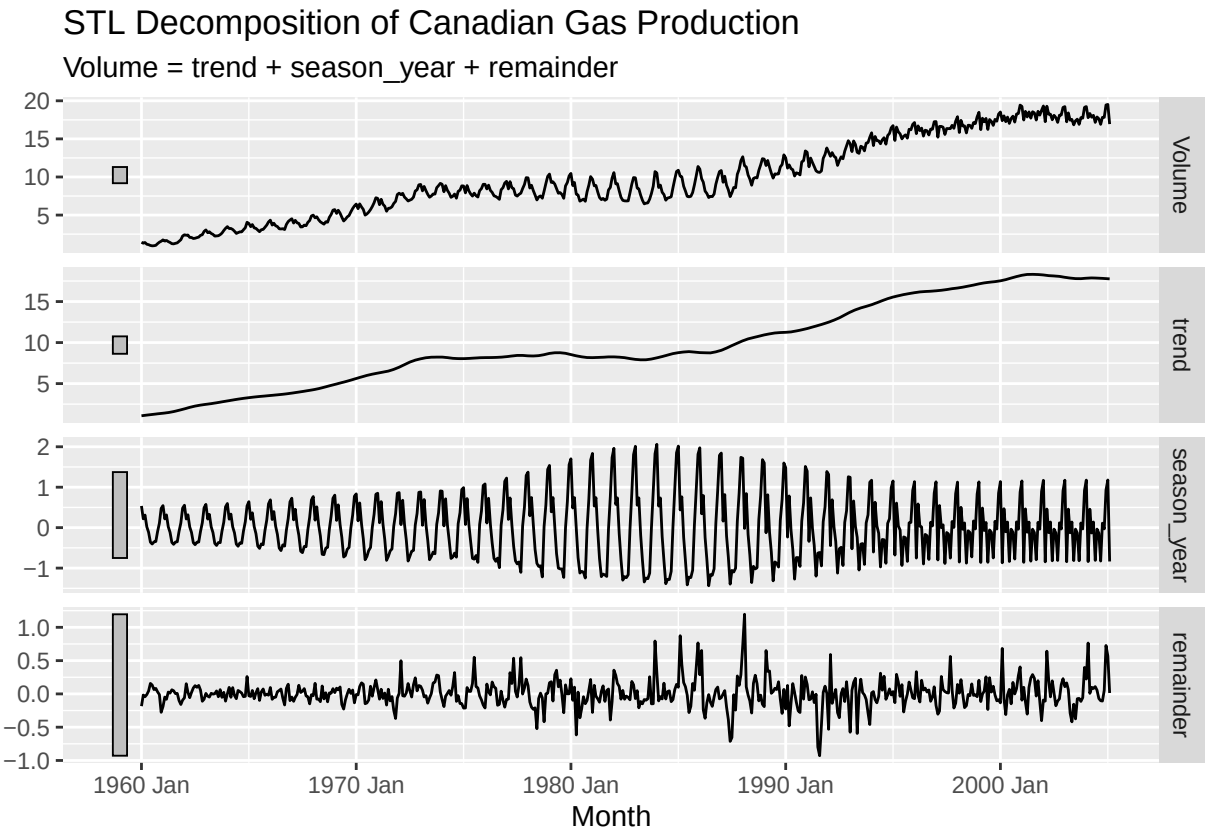

```
# X-11
cgas_dx11 <- canadian_gas |>
  model(
    x11 = X_13ARIMA_SEATS(Volume ~ x11())
  ) |>
  components()
cgas_dx11 |>
  autoplot() +
  labs(
    title = "X-11 Decomposition of Canadian Gas Production"
  )
```




```
# SEATS
cgas_dseats <- canadian_gas |>
  model(
    seats = X_13ARIMA_SEATS(Volume ~ seats())
  ) |>
  components()
cgas_dseats |>
  autoplot() +
  labs(
    title = "SEATS Decomposition of Canadian Gas Production"
  )
```



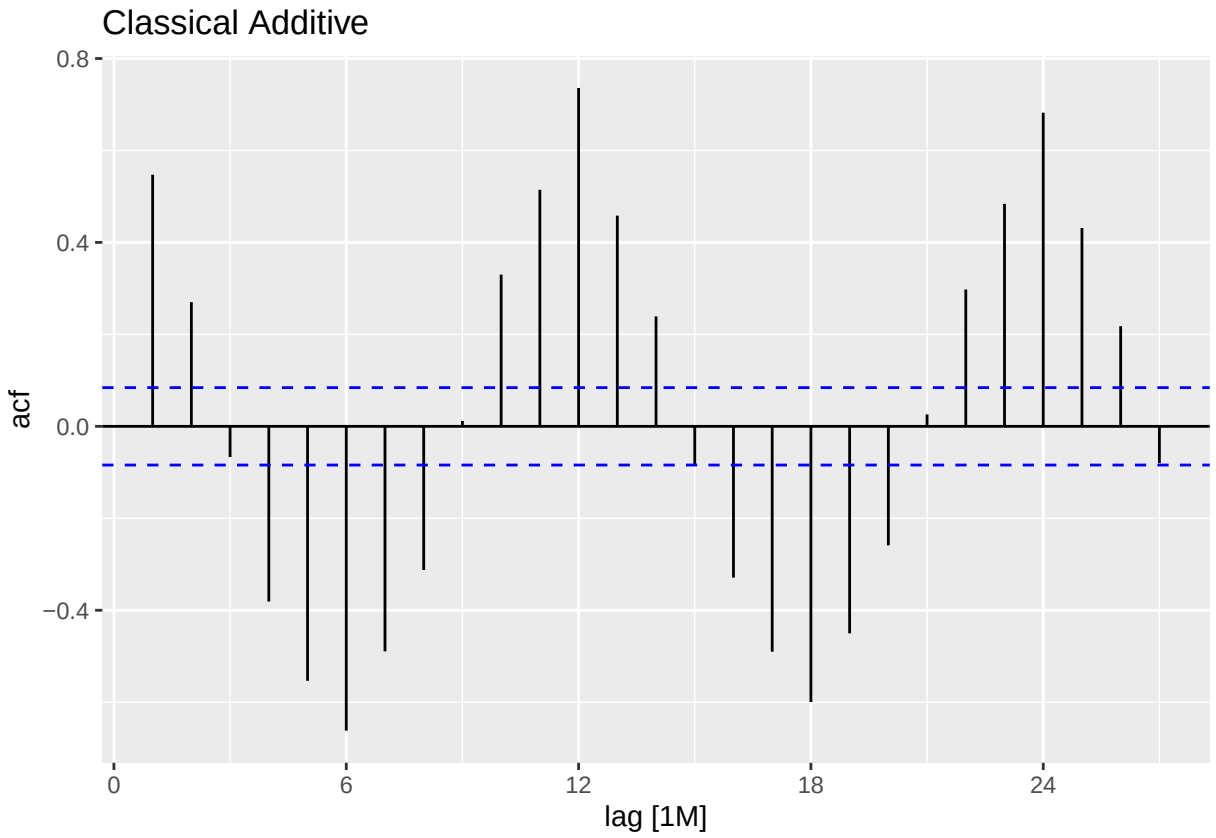

```
# STL
cgas_dstl <- canadian_gas |>
  model(
    STL(Volume, robust = TRUE) # 注意这里启用了 robust 设定
  ) |>
  components()
cgas_dstl |>
  autoplot() +
  labs(
    title = "STL Decomposition of Canadian Gas Production"
  )
```



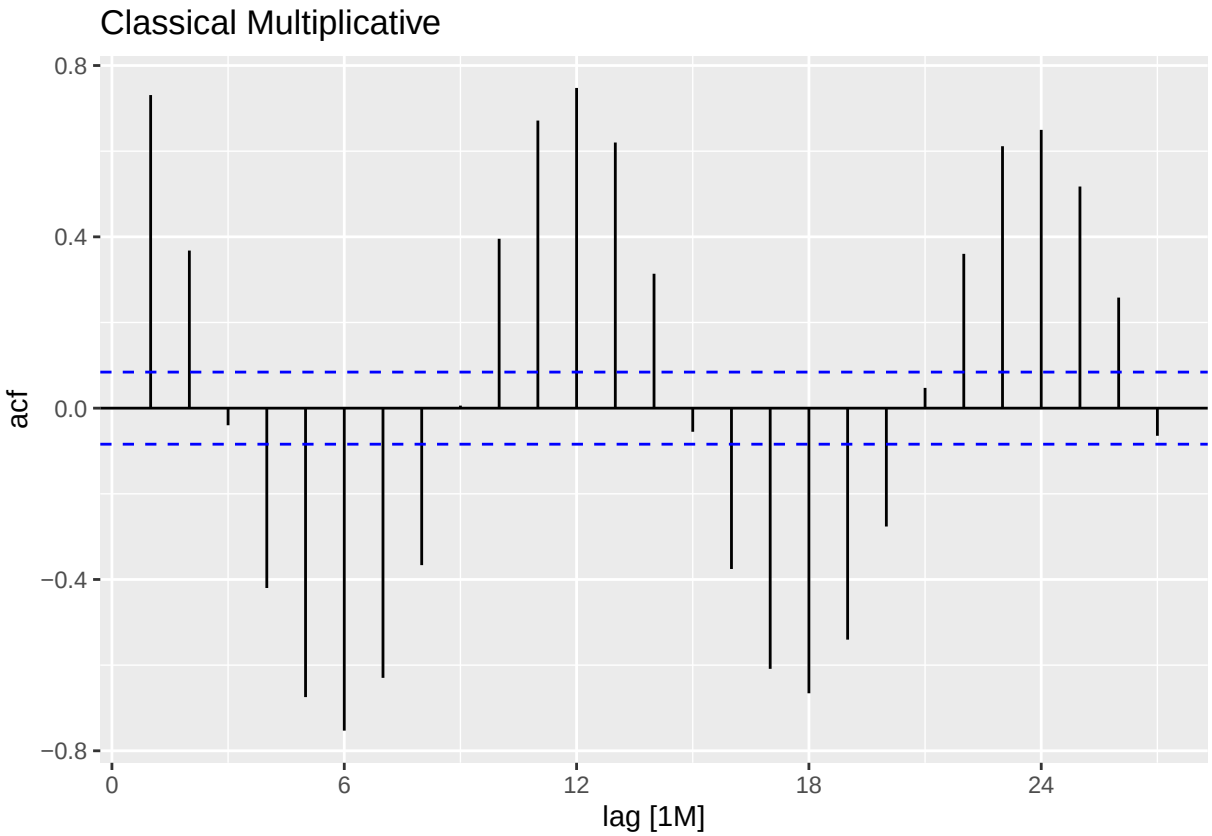
可以从趋势周期项的平滑度、季节项是固定还是可变、剩余项的特征等方面进行比较。

iii. 针对第 ii 问中五种分解结果中的剩余项分别绘制自相关图（注意不同分解结果中保存剩余项的变量名称）。各种方法是否有效去除了趋势和季节性特征?

```
cgas_dclassic_add |>
  ACF(random) |>
  autoplot() +
  labs(title = "Classical Additive")
```

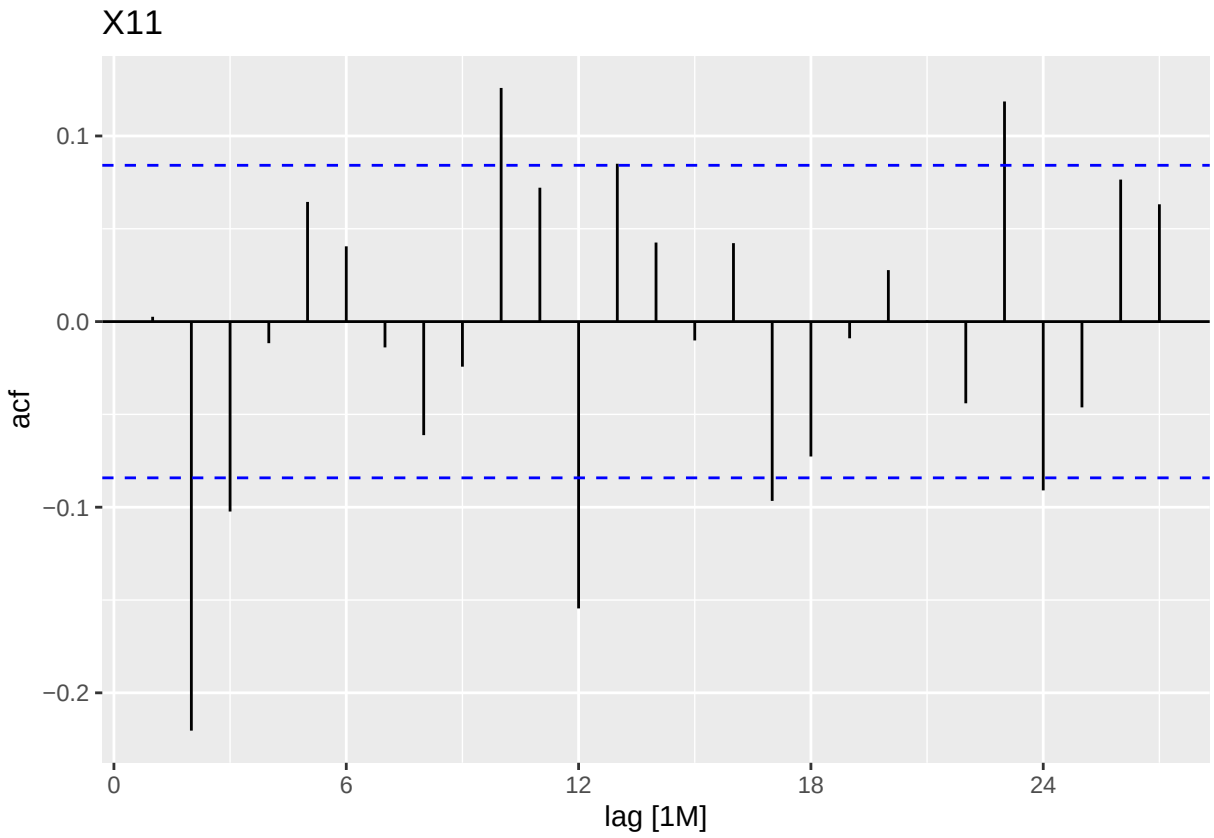



```
cgas_dclassic_multi |>
  ACF(random) |>
  autoplot() +
  labs(title = "Classical Multiplicative")
```

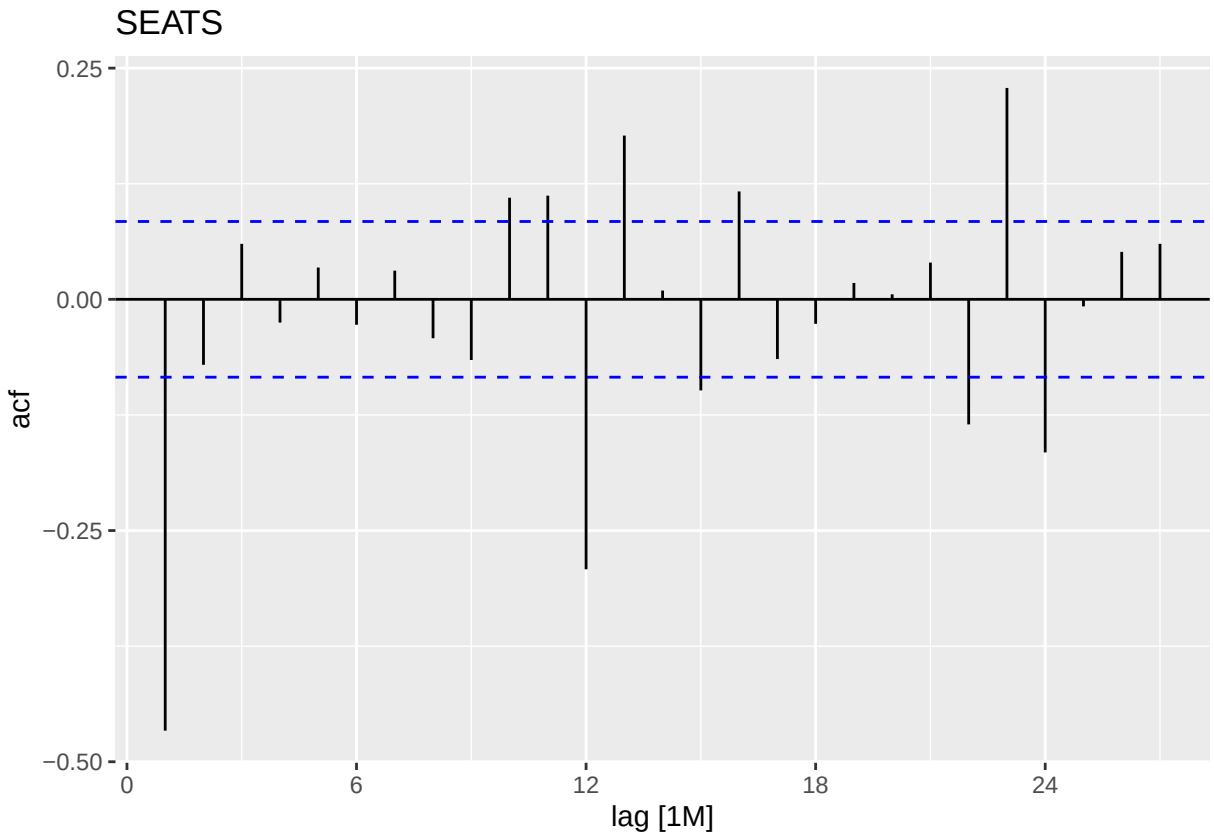


传统分解法的加法模型和乘法模型的剩余项中保留了明显的季节性特征。

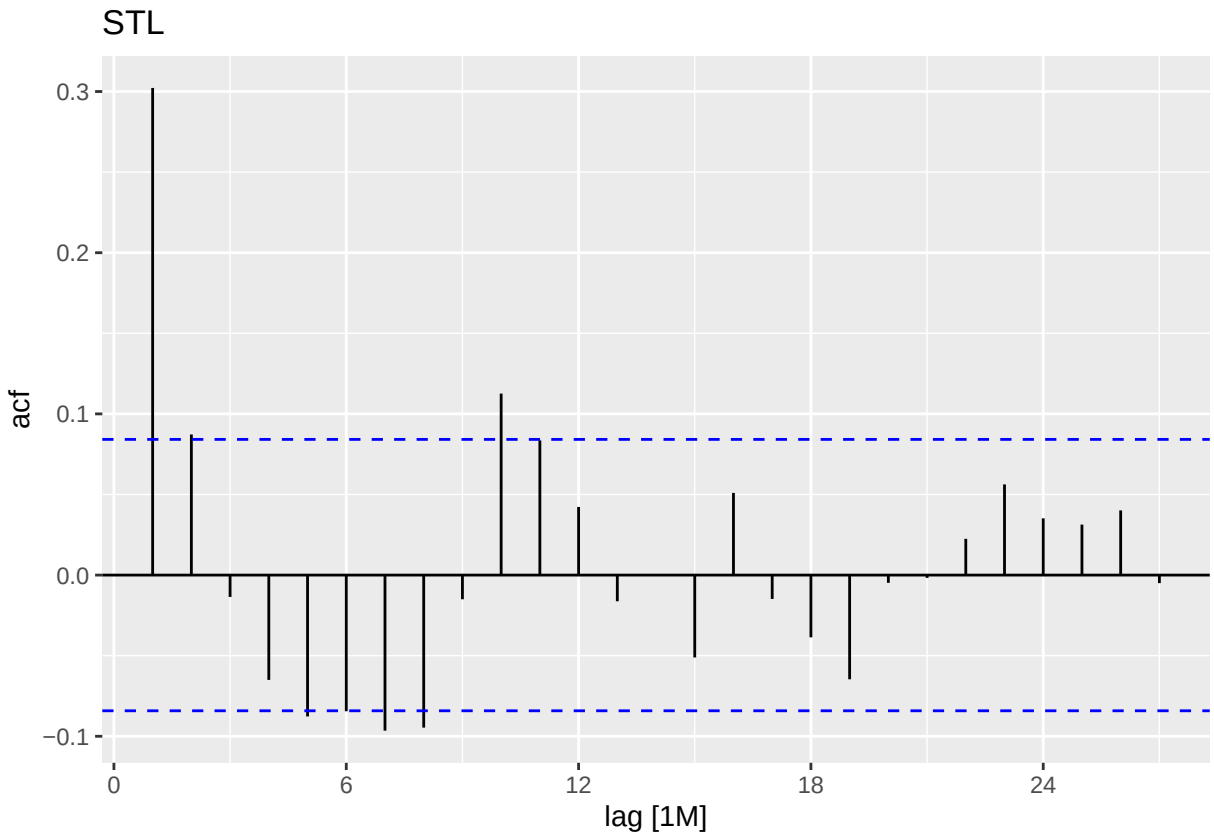
```
cgas_dx11 |>
  ACF(irregular) |>
  autoplot() +
  labs(title = "X11")
```




```
cgas_dseats |>
  ACF(irregular) |>
  autoplot() +
  labs(title = "SEATS")
```




```
cgas_dstl |>
  ACF(remainder) |>
  autoplot() +
  labs(title = "STL")
```



从 X-11、SEATS 和 STL 的剩余项自相关图中无法明确判断季节性的存在。

需要注意的是，此处的 STL 分解启用了 `robust` 设定，如果你没有启用该设定（默认是不启用），则分解结果会有所不同。