

# 13-Identification of Breakpoints in Time Series

2023-11-08

## 1 Text needs to be written

The example is adapted from the help pages of R package “strucchange”, see Zeileis, A. et al. (2002), Journal of Statistical Software, 7(2), <https://www.jstatsoft.org/v07/i02/>

```
library(strucchange)
```

Lade nötiges Paket: zoo

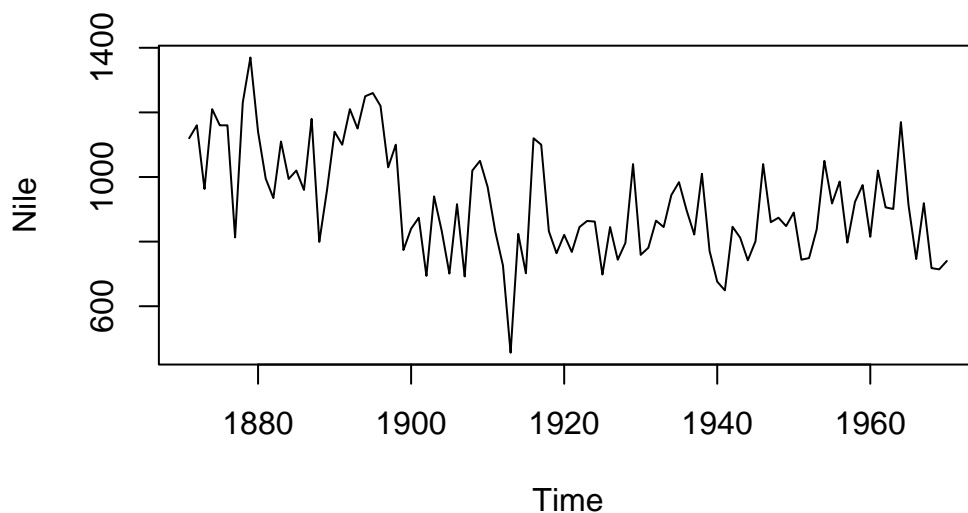
Attache Paket: 'zoo'

Die folgenden Objekte sind maskiert von 'package:base':

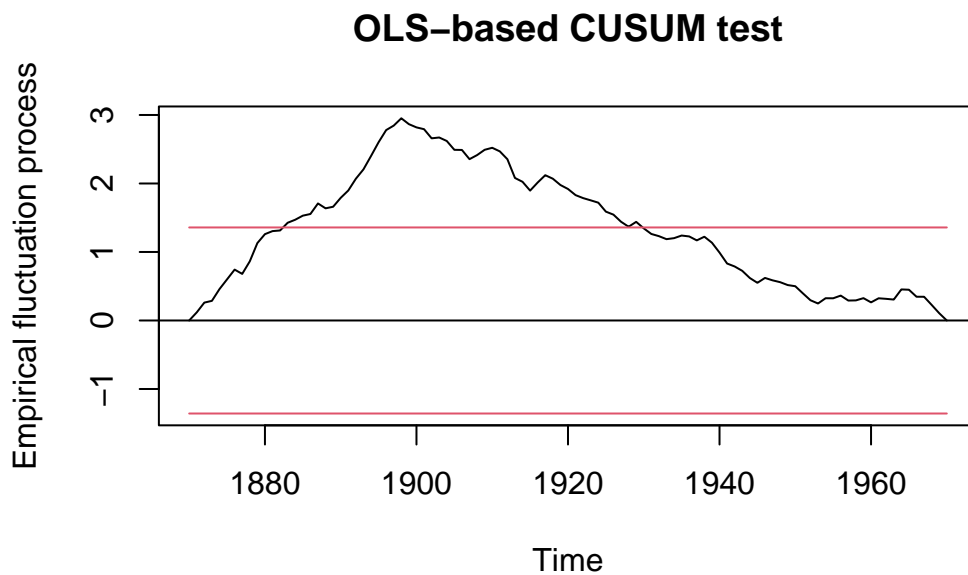
as.Date, as.Date.numeric

Lade nötiges Paket: sandwich

```
data("Nile")  
plot(Nile)
```



```
## OLS-CUSUM test for structural breaks in the time series
## are there periods with different discharge?
ocus <- efp(Nile ~ 1, type = "OLS-CUSUM")
plot(ocus)
```



```
sctest(ocus)
```

OLS-based CUSUM test

```
data: ocus
S0 = 2.9518, p-value = 5.409e-08
```

```
## identify time of structural break (with respect to mean value)
bp.nile <- breakpoints(Nile ~ 1)
summary(bp.nile)
```

Optimal (m+1)-segment partition:

```
Call:
breakpoints.formula(formula = Nile ~ 1)
```

Breakpoints at observation number:

```
m = 1      28
m = 2      28      83
m = 3      28      68 83
m = 4      28 45 68 83
m = 5      15 30 45 68 83
```

Corresponding to breakdates:

```
m = 1      1898
```

```

m = 2      1898      1953
m = 3      1898      1938 1953
m = 4      1898 1915 1938 1953
m = 5  1885 1900 1915 1938 1953

```

Fit:

```

m    0      1      2      3      4      5
RSS 2835157 1597457 1552924 1538097 1507888 1659994
BIC   1318   1270   1276   1285   1292   1311

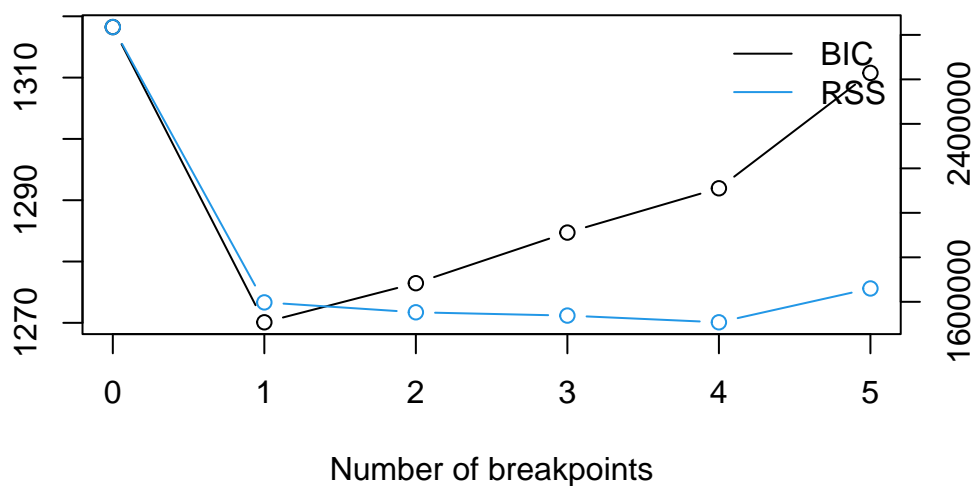
```

```

## the BIC also chooses one breakpoint
plot(bp.nile)

```

## BIC and Residual Sum of Squares



```

## fit null hypothesis model and model with 1 breakpoint
fm0 <- lm(Nile ~ 1)
fm1 <- lm(Nile ~ breakfactor(bp.nile, breaks = 1))
plot(Nile)
lines(ts(fitted(fm0), start = 1871), col = 3)
lines(ts(fitted(fm1), start = 1871), col = 4)
lines(bp.nile)

## confidence interval
ci.nile <- confint(bp.nile)
ci.nile

```

Confidence intervals for breakpoints  
of optimal 2-segment partition:

Call:

```
confint.breakpointsfull(object = bp.nile)
```

Breakpoints at observation number:

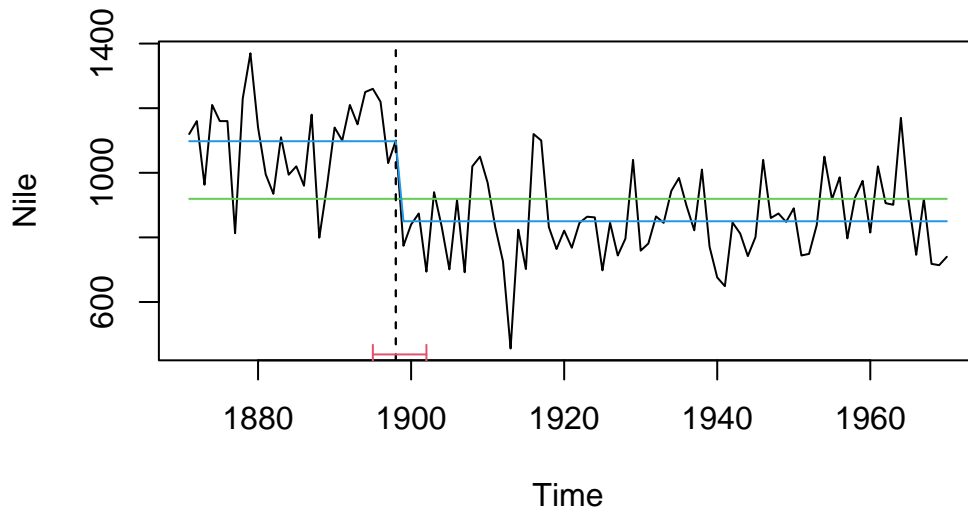
2.5 % breakpoints 97.5 %

```
1      25          28      32
```

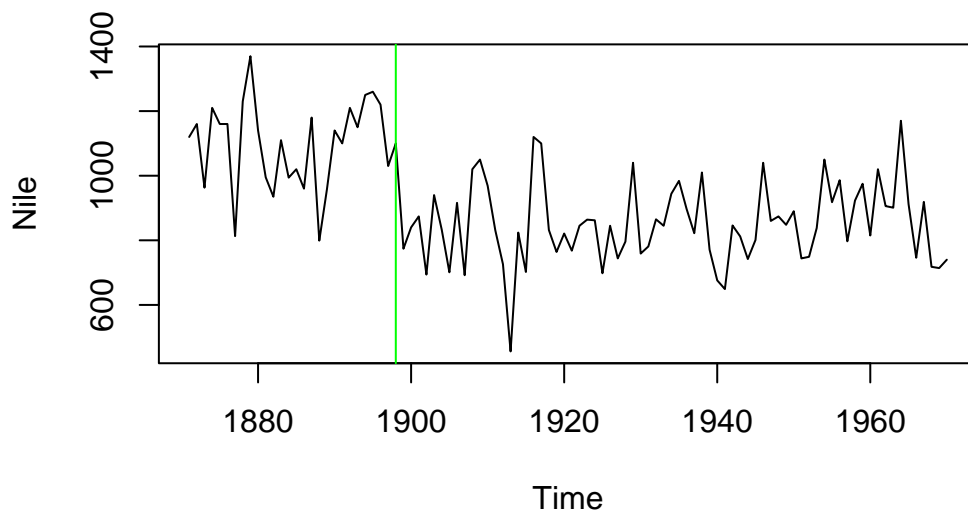
Corresponding to breakdates:

```
2.5 % breakpoints 97.5 %
1 1895          1898  1902
```

```
lines(ci.nile)
```



```
## mark breakpoint using a simpler (and less fancy) method
plot(Nile)
dat <- data.frame(time = time(Nile), Q = as.vector(Nile))
abline(v=dat$time[bp.nile$breakpoints], col="green")
```



```
## ANOVA test whether the two models are significantly different
anova(fm0, fm1)
```

Analysis of Variance Table

Model 1: Nile ~ 1

Model 2: Nile ~ breakfactor(bp.nile, breaks = 1)

Res.Df	RSS	Df	Sum of Sq	F	Pr(>F)
--------	-----	----	-----------	---	--------

```
1      99 2835157
2      98 1597457  1   1237700 75.93 7.439e-14 ***
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## alternative: AIC-based model comparison.
```

```
## The model with lower AIC is better
```

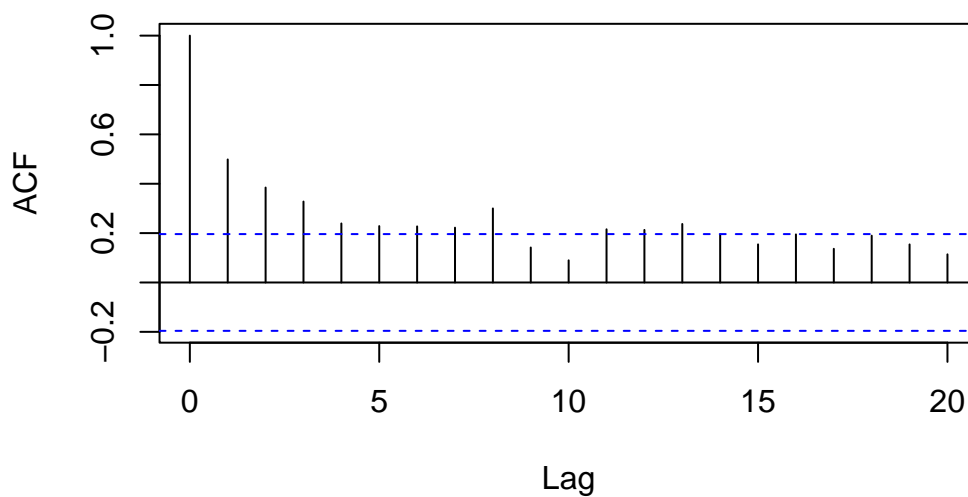
```
AIC(fm0,fm1)
```

```
      df      AIC
fm0  2 1313.031
fm1  3 1257.663
```

```
## some tests for quality and assumptions of the fitted model
```

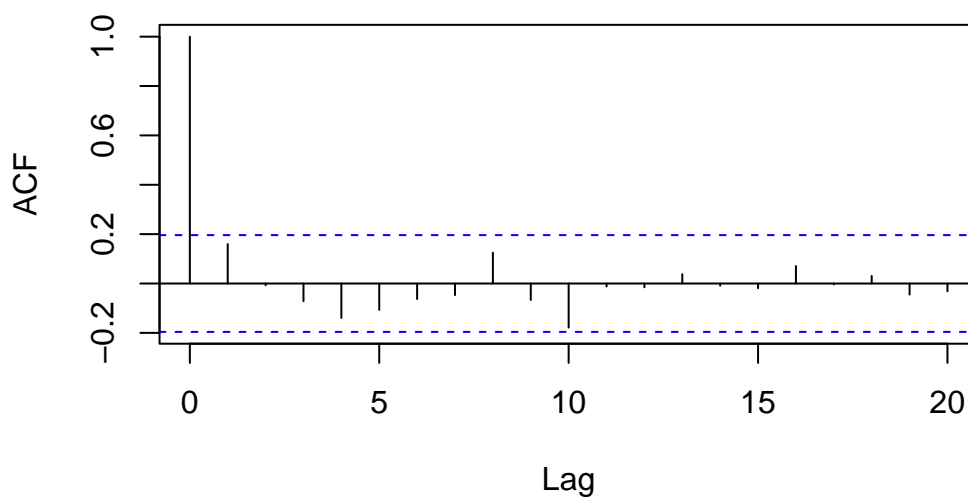
```
acf(residuals(fm0))
```

### Series residuals(fm0)



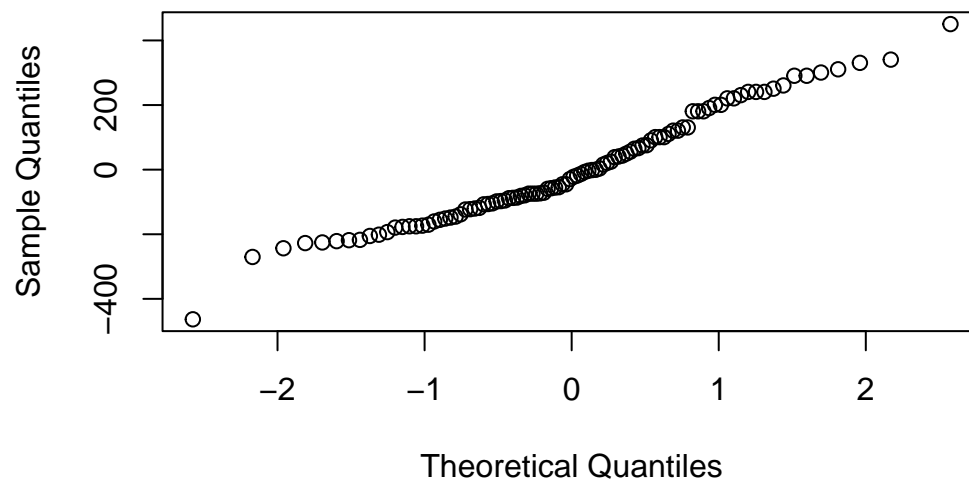
```
acf(residuals(fm1))
```

### Series residuals(fm1)



```
qqnorm(residuals(fm0))
```

**Normal Q–Q Plot**



```
qqnorm(residuals(fm1))
```

**Normal Q–Q Plot**

