ArDec Tutorial

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Introduction

This document contains simple illustrative examples of usage of the R-package ArDec.

The pakage ArDec implements a time series decomposition procedure based on the dynamic linear representation of an autoregressive process. The procedure was found particularly useful for the extraction of trend and periodic components from long (monthly) climate records.

Getting started

Download the package from CRAN (`http://cran.r-project.org`) or in R

```
> install.packages(''ArDec'')
```

Load the library

```
> library(ArDec)
```

Start the help system

```
> help.start()
```

Data

Load the example data (monthly temperature in Central England from 1723-1970)

```
> data(tempEng)
```

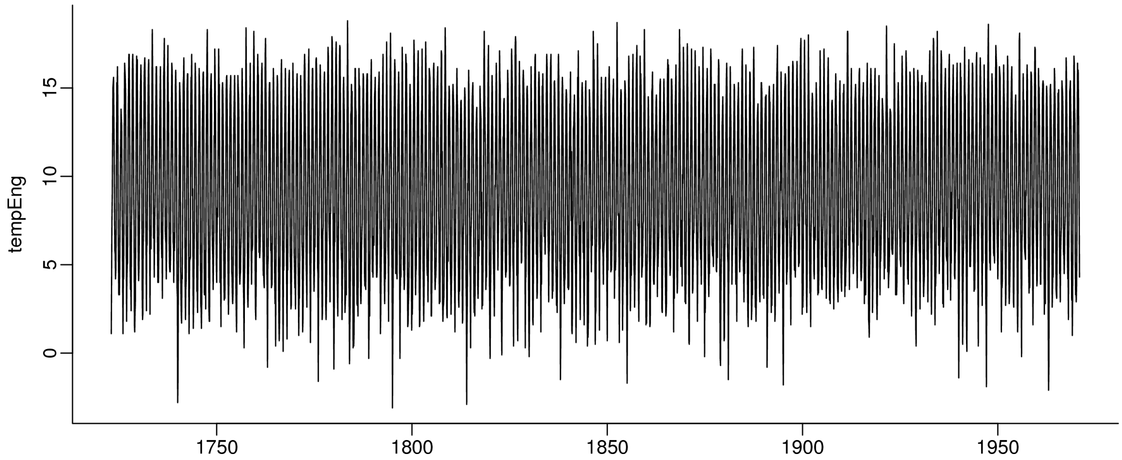
Check the structure of this R object

```
> str(tempEng)
```

```
> Time-Series [1:2976] from 1723 to 1971: 1.1 4.4 7.5 8.9 11.7 15 15.3 15.6
```

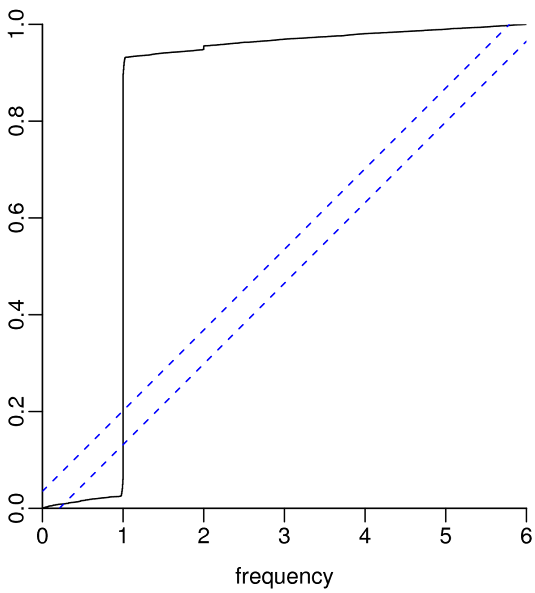
Plot the data

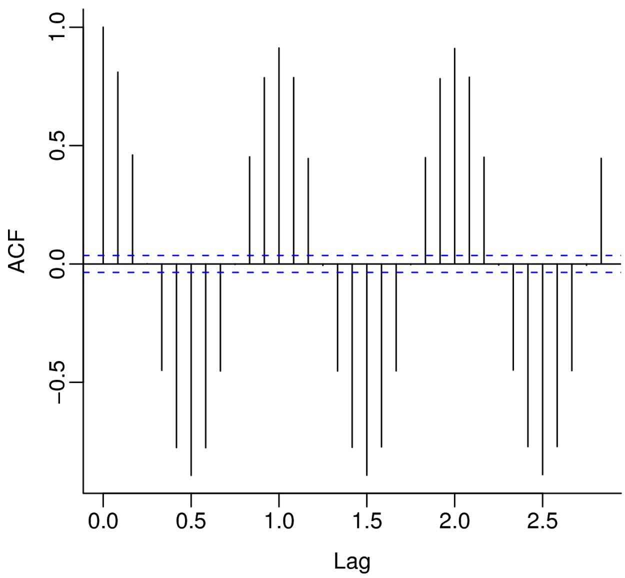
```
> plot(tempEng)
```



Some exploratory time series analysis

```
> cpgram(tempEng)
> acf(tempEng)
```





The time series plot, the cumulative periodogram and the sample autocorrelation function show a strong annual periodicity in the data. The next section illustrates how to decompose this time series using ArDec

ArDec decomposition

1. Fitting an autoregressive process to the data

```
> model=ardec.lm(tempEng)
```

In this case the method used to fit the model is not specified, so the Burg method is used. A big model (order of the autoregressive parameter $p = 34$) is fitted to the time series of temperature in central England

```
> model
Call: lm(formula = y ~ -1 + X, x = TRUE)
Coefficients:
       X1          X2          X3          X4          X5          X6
 0.2942447   0.0480123  -0.0166935  -0.0050246  -0.0119893   0.0090816
       X7          X8          X9         X10         X11         X12
-0.0233188  -0.0382977   0.0053468   0.0562919   0.0622145   0.1043717
      X13         X14         X15         X16         X17         X18
 0.0549423  -0.0598093  -0.0373727  -0.0317938  -0.0089850  -0.0259883
      X19         X20         X21         X22         X23         X24
-0.0002747  -0.0513517   0.0027275   0.0270081   0.0493173   0.1266952
      X25         X26         X27         X28         X29         X30
 0.1025295   0.0093870  -0.0639103  -0.0136526  -0.0274514  -0.0336428
      X31         X32         X33         X34
-0.0130935  -0.0382225  -0.0088768   0.0443993
```

2. ArDec core decomposition, based on the parameters estimated above

```
> coef=model$coefficients
> decomposition=ardec(tempEng,coef)
```

The previous command gives an object (decomposition) of class ardec

```
> str(decomposition)
Formal class 'ardec' [package "ArDec"] with 5 slots
..@ start    : num [1:2] 1723 1
..@ frequency: num 12
..@ period   : num [1:34] 12 -12 5.99 -5.99 8.42 ...
..@ modulus  : num [1:34] 1 1 0.964 0.964 0.946 ...
..@ comps    : cplx [1:34, 1:2976]  NA  NA  NA ...
```

This object is a list, containing information on the time series (start period and frequency) and information on the estimated components (period, modulus or damping factor and all the 34 components themselves).

Well, this is not a very practical way of looking at the decomposition results. The output includes both signs of the imaginary eigenvalues obtained from the canonical matrix (see the references for the mathematical details), so the period shows the two (positive and negative) values, for the same modulus (real part of the eigenvalue). Furthermore, although ArDec extracts as many components as the estimated order for the autoregressive process (in this case 34), not all are of interest or meaningful - only the components least damped (with modulus closer to 1) are relevant. So... up to the next function, ardec.components.

3. Extraction of the main components

The function ardec.components retrieves from the ArDec decomposition (the object of class ardec) the components whose modulus exceeds a given threshold (the default value is set to 0.95)

```
> output=ardec.components(decomposition, th = 0.95)
```

The result is a list with the ArDec components with modulus greater than the specified threshold

```
> str(output)
```

```
List of 2
$ periodcomps:List of 2
..$ periods: num [1:2] 12 6
..$ comps  : mts [1:2976, 1:2] NA NA NA NA NA NA NA NA NA NA ...
.. ..- attr(*, "dimnames")=List of 2
.. .. ..$ : NULL
.. .. ..$ : chr [1:2] "Series 1" "Series 2"
.. ..- attr(*, "tsp")= num [1:3] 1723 1971 12
.. ..- attr(*, "class")= chr [1:2] "mts" "ts"
$ trendcomp  : Time-Series [1:2976] from 1723 to 1971: NA NA NA NA NA NA NA ... >
```

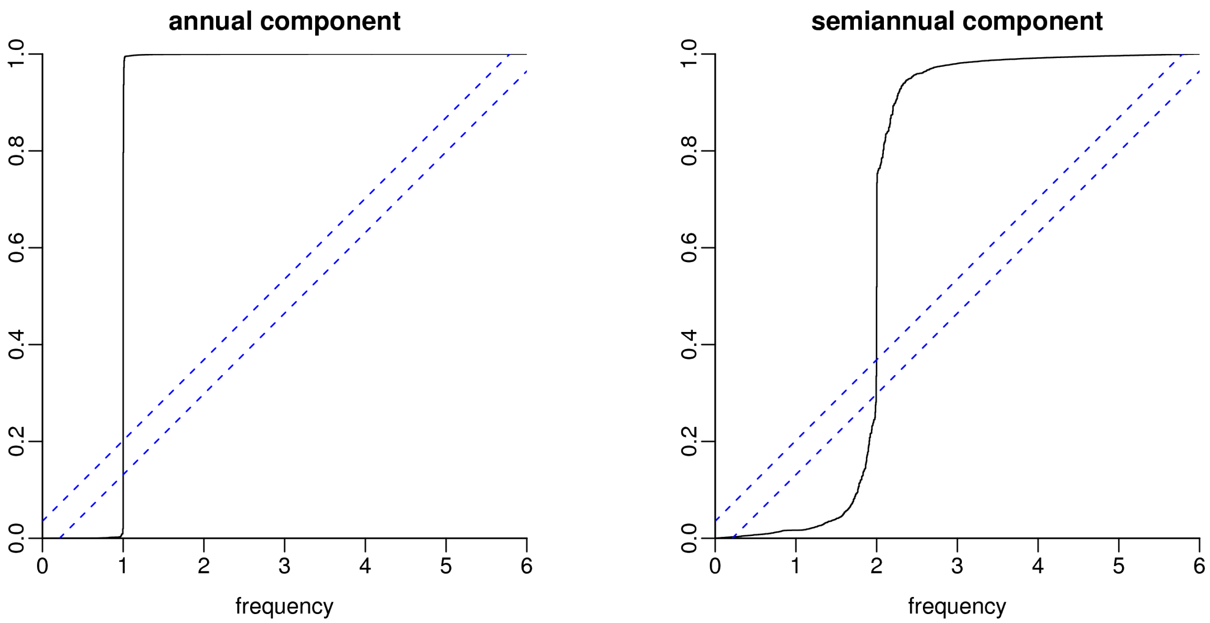
The list contains first the periodic components (in this case a 12 months and a 6 months cycles) and a trend component (note: the first values of the components are missing due to the filtering involved in the autoregressive fit).

The components can be set as an independent R object

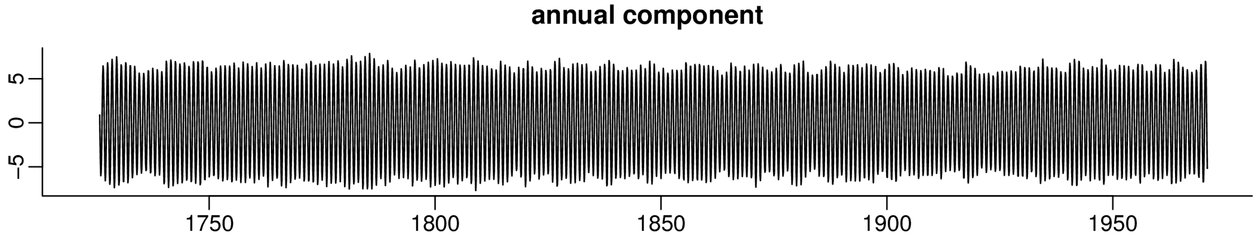
```
> annual=ts(output$periodcomps$comps[,1],start=1723,frequency=12)
> semiannual=ts(output$periodcomps$comps[,2],start=1723,frequency=12)
> trend=ts(output$trendcomp,start=1723,frequency=12)
```

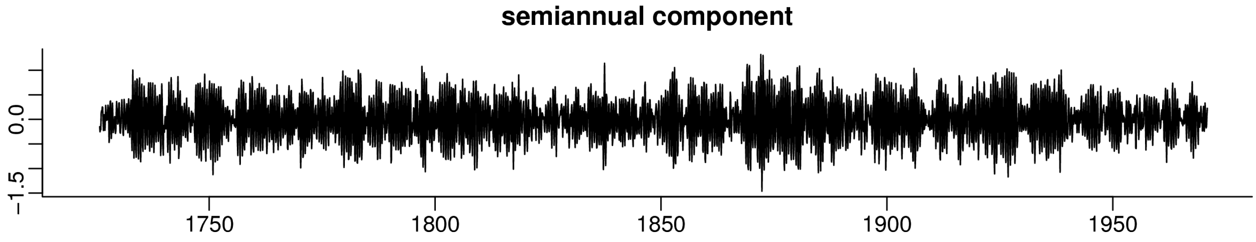
And further analysed

```
> cpgram(annual)
> cpgram (semiannual)
```



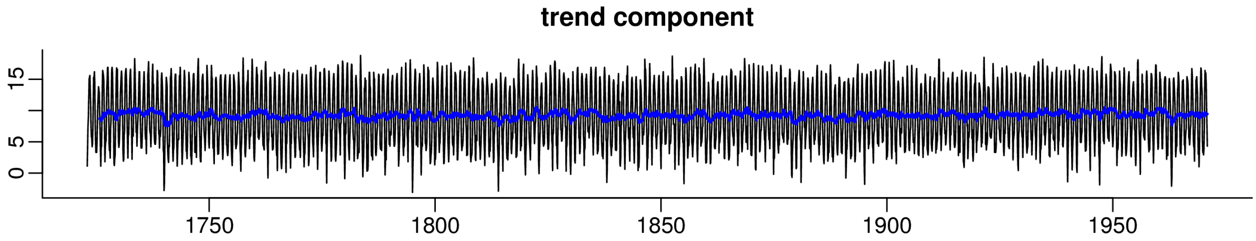

```
> plot(annual,xlab="",ylab="",main="annual component")
> plot(semiannual,xlab="",ylab="",main="semiannual component")
```

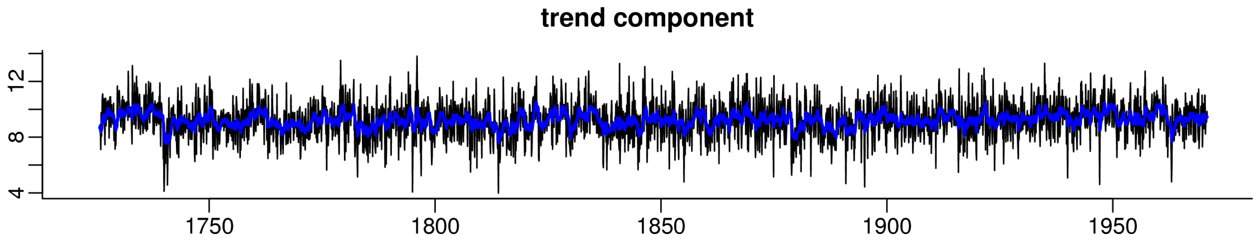





```
> plot(tempEng,xlab="",ylab="",main="trend component")
> lines(trend+mean(tempEng),col=4,lwd=2)

> plot(tempEng-annual,xlab="",ylab="",main="trend component")
> lines(trend+mean(tempEng),col=4,lwd=2)
```





References

When using this software please cite

- Barbosa, SM, Silva, ME, Fernandes, MJ (2008), Changing seasonality in North Atlantic coastal sea level from the analysis of long tide gauge records. Tellus, 60A, 165-177.
- West, M. (1997), Time series decomposition. Biometrika, 84, 489-494.