Practical work

L. DELSOL

Time Series Simulation and Analysis

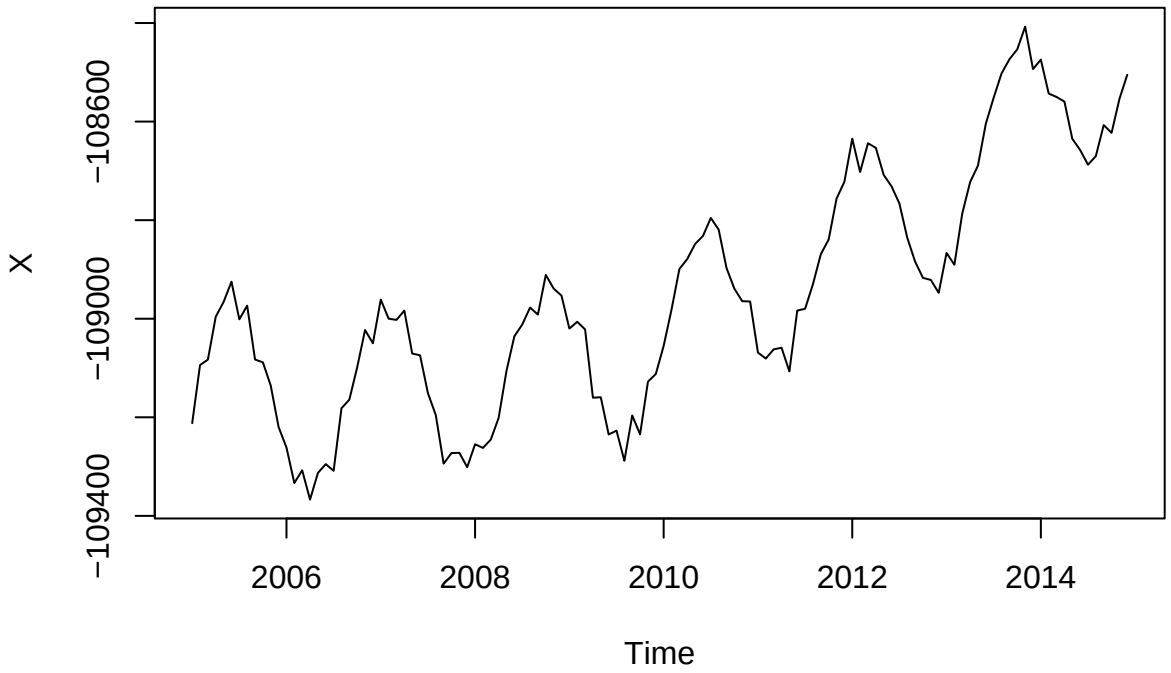
The goal of this exercise is to familiarize you further with the simulation, modeling, and statistical analysis of time series. In addition to your report—which should contain answers to the questions and the relevant graphs—please remember to submit the script containing all the commands used, as well as a saved copy of your workspace: ***DM.RData***.

```
##### random parameters
a=rnorm(1,10,2)
b=rnorm(1,12400,100)
tau=sample(6:24,1)
##### simulations
time=seq(2005,2014+11/12,1/12)
Te=a*time^2-a*4013*time+(a*4014010+b)
S=rep_len(180*sin((0:(tau-1))*2*pi/tau),120)
E=rnorm(120,0,30)
X=ts(Te+S+E,start=c(2005,1),freq=12)
##### Saving the workspace
save(list=c('time','T','S','E','X'),file="DM.RData")
```

First, enter the following commands: *The last command saves the variables you have just created. This is essential because they are randomly generated and therefore must not be regenerated every time you restart R (otherwise, you would have to start all over again).*

1. Explain the meaning of each command in the **simulations** section. What do Te, S, E, and X represent?
2. Plot the time series obtained in the previous question. Comment on the result (model type, shape of the trend, period, etc.).

```
plot(X)
```



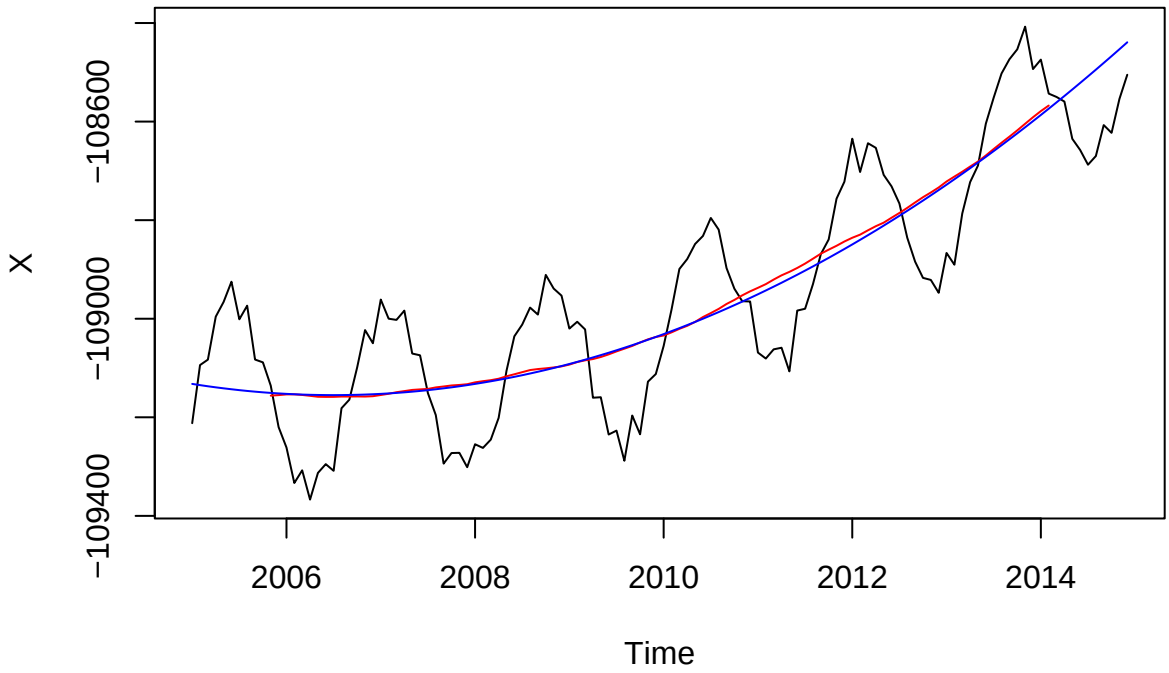

```
# period
tau
```

```
## [1] 20
```

```
# additive model
# non-linear trend (hyperbolic)
```

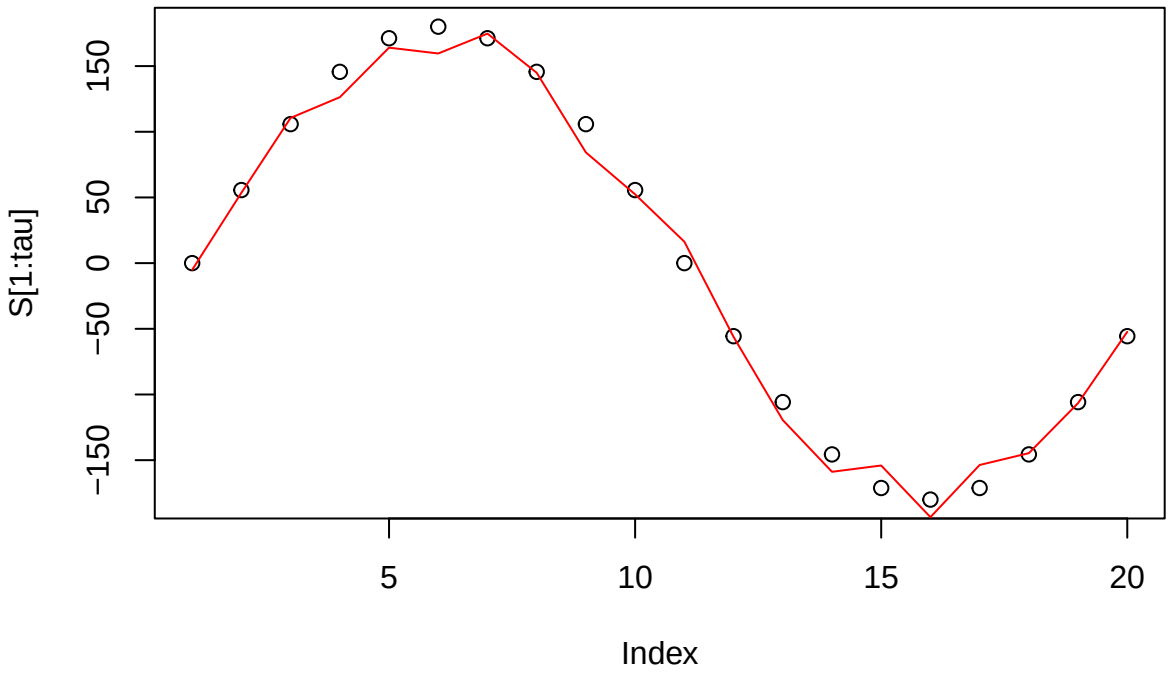
3. Use a moving average with an appropriate period to estimate the trend. Plot the moving average and T (using time on the x-axis) on the graph obtained in the previous question. Comment on the result.

```
# moving average of order tau
if (tau%%2==0){moymob=filter(X,c(.5,rep(1,tau-1),.5)/tau)}
if (tau%%2==1){moymob=filter(X,rep(1,tau)/tau)}
plot(X)
lines(moymob,col="red")
lines(time,Te,col='blue')
```



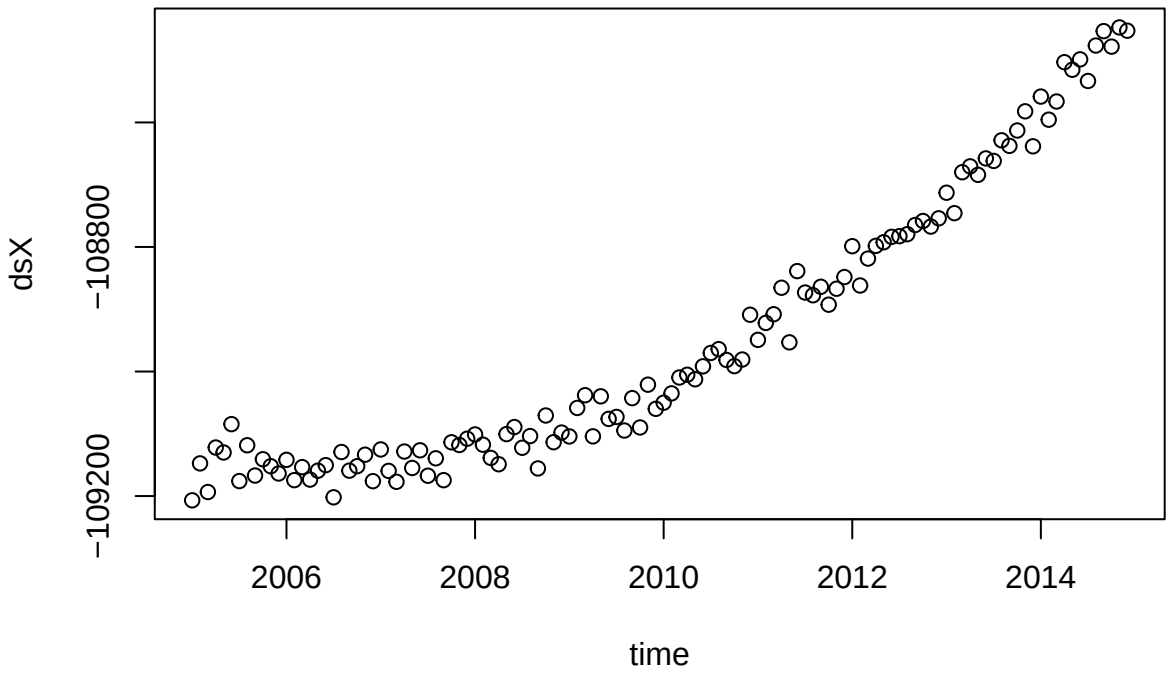
4. Calculate the seasonal coefficients. Plot the obtained seasonal coefficients and S (over one period) on the same graph. Comment on the result.

```
# Number of complete cycles
N=floor(120/tau)
Z=X-moymob
p=tau
Sais=rep(NA,tau)
for (i in 1:tau)
{
  if (i<=floor(tau/2)) {Sais[i]=mean(Z[i+tau*(1:(N-1))])}
  else {Sais[i]=mean(Z[i+tau*(0:(N-2))])}
}
plot(S[1:tau])
lines(Sais,col='red')
```



5. Obtain the deseasonalized series dsX from the seasonal coefficients. Plot it against time. What do you observe in the resulting scatter plot?

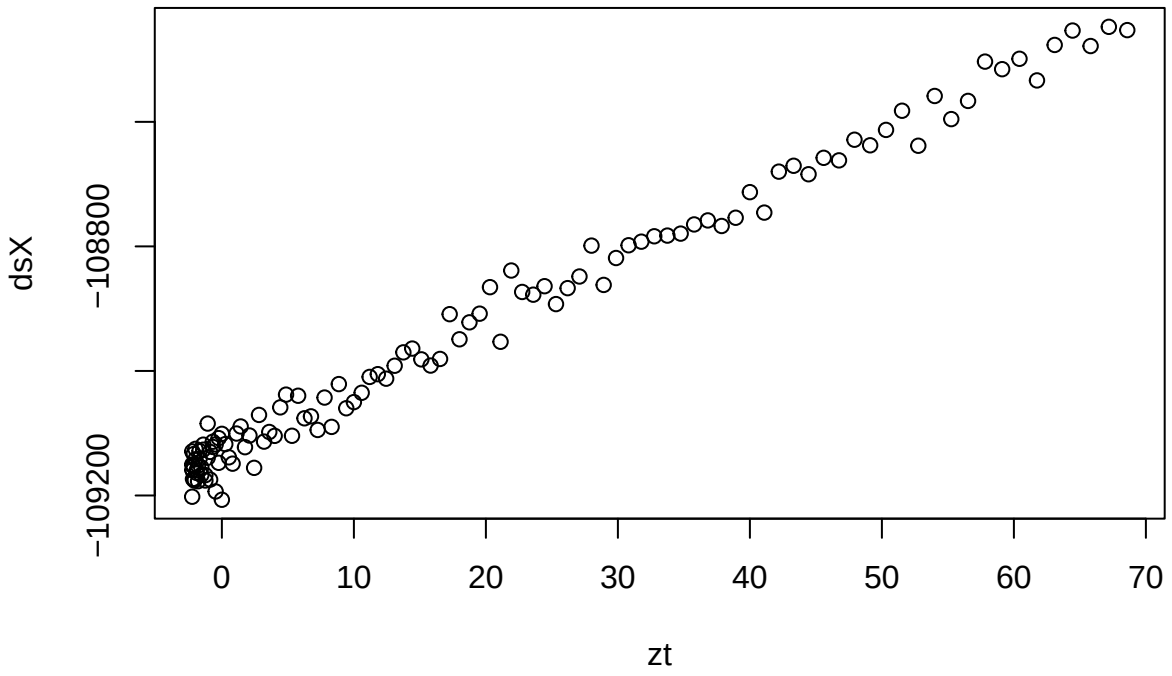
```
dsX=X-rep_len(Sais,120)
plot(time,dsX,type='p')
```




```
# non-linear scatter plot, variable transformation necessary
```

6. Introduce a new variable `zt = (time-2005)^2-3*(time-2005)` Plot the scatter plot of **dsX** against **zt**. Comment on the result.

```
zt = (time-2005)^2-3*(time-2005)
plot(zt,dsX,type='p')
```




```
# linear scatter plot, positive slope
```

7. Calculate the correlation coefficient. Comment on the result.

```
cor(zt,dsX)
```

```
## [1] 0.9936385
```

```
# confirms strong linear relationship and positive slope
```

8. Based on the previous questions, derive a model for the trend (provide its equation and interpret the parameter values) and describe the model's quality.

```
##
## Call:
## lm(formula = dsX ~ zt)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -75.382 -18.995   2.244  17.559  67.909
##
## Coefficients:
##               Estimate Std. Error   t value Pr(>|t|)
## (Intercept) -1.091e+05  2.987e+00 -36531.45   <2e-16 ***
## zt           1.025e+01  1.070e-01     95.84   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 24.98 on 118 degrees of freedom
## Multiple R-squared:  0.9873, Adjusted R-squared:  0.9872
## F-statistic:  9186 on 1 and 118 DF,  p-value: < 2.2e-16
```

```
## dsX= 10.25367 zt+ -109131.5
```

```
## R2= 0.9873174
```

```
## very good model quality
```

9. Finally, provide an estimate of the time series values for the entire year of 2015 (pay attention to the change of variable!).

```
##         1         2         3         4         5         6         7         8
## -88414.69 -88363.66 -88322.98 -88296.56 -88286.90 -88294.85 -88319.57 -88358.53
##         9        10        11        12
## -88407.86 -88462.63 -88517.39 -88566.72
```

