STAT429 HW06

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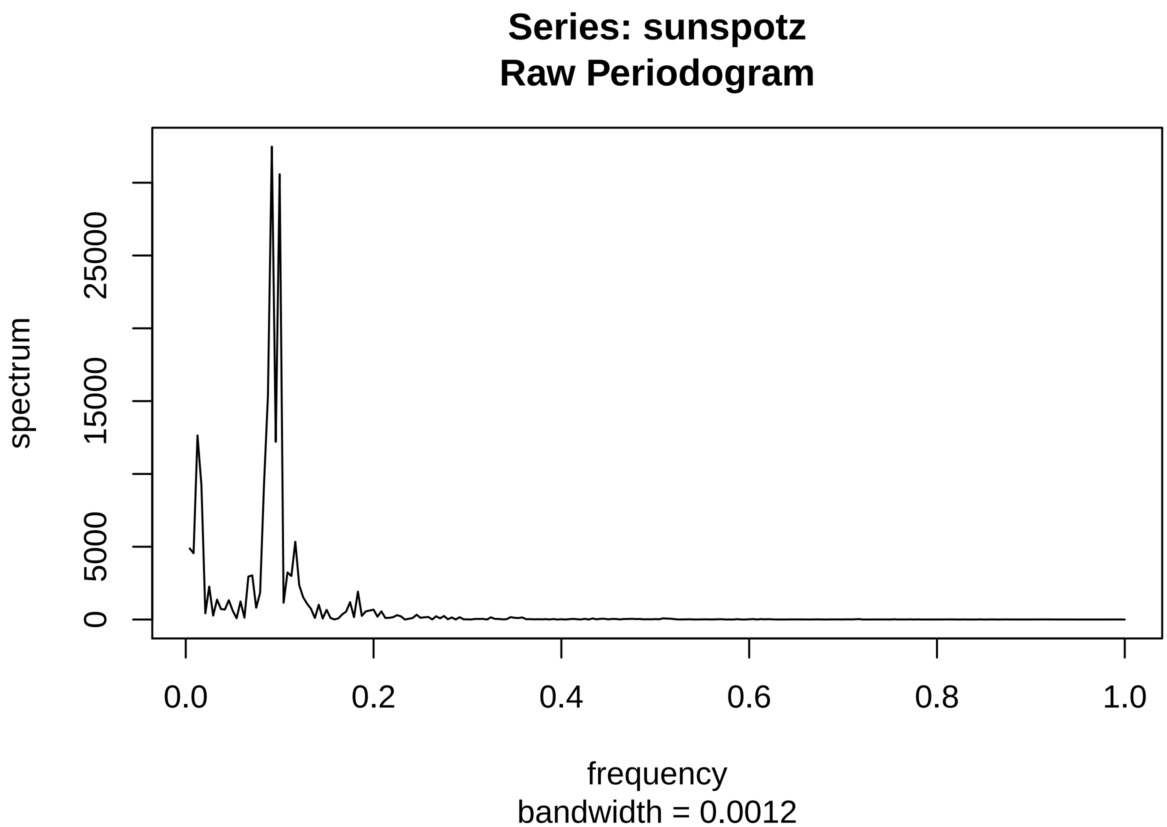
Question3

```r
library(astsa)
```

```
## Warning: package 'astsa' was built under R version 3.4.3
```

```r
data(sunspotz)
per= spec.pgram(sunspotz,taper=0, log="no")
```




```r
1/(which(per$spec==sort(per$spec,decreasing = TRUE)[1])/per$n.used)
```

```
## [1] 21.81818
```

```r
1/(which(per$spec==sort(per$spec,decreasing = TRUE)[2])/per$n.used)
```

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

```r
1/(which(per$spec==sort(per$spec,decreasing = TRUE)[3])/per$n.used)
```

```
## [1] 22.85714
```

```r
1/(which(per$spec==sort(per$spec,decreasing = TRUE)[4])/per$n.used)
```

```
## [1] 160
```

There are 4 predominant periods, 22, 20, 23, 160 but the third one is not predominant period in the periodogram. Then I omit the third one and conclude that 22, 20, 160 is the predominant cycle. Because each year has 2 observations, we can also say that the predominat periods are 10, 11, and 80.

```
U = qchisq(.025,2)
L = qchisq(.975,2)
2*per$spec[22]/L
```

```
## [1] 8804.265
```

```
2*per$spec[22]/U
```

```
## [1] 1282807
```

```
2*per$spec[24]/L
```

```
## [1] 8290.672
```

```
2*per$spec[24]/U
```

```
## [1] 1207975
```

```
2*per$spec[3]/L
```

```
## [1] 3428.087
```

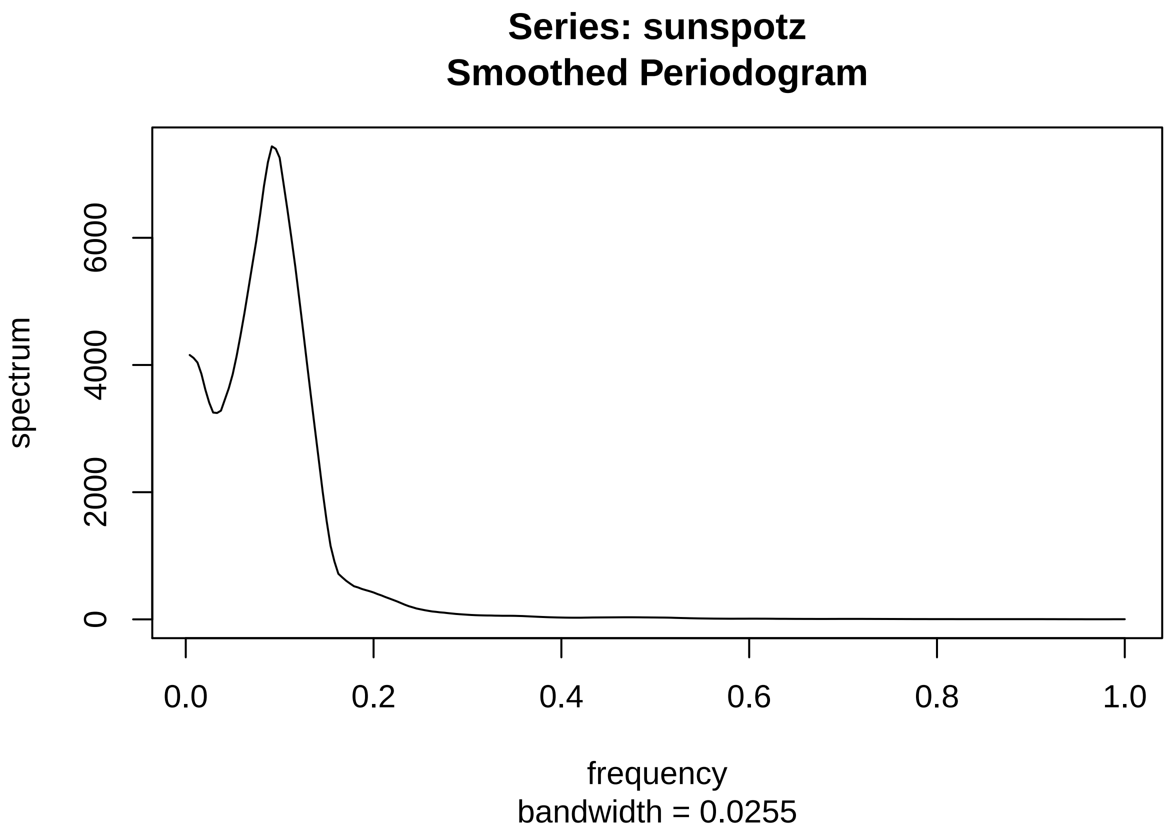
```
2*per$spec[3]/U
```

```
## [1] 499482.4
```

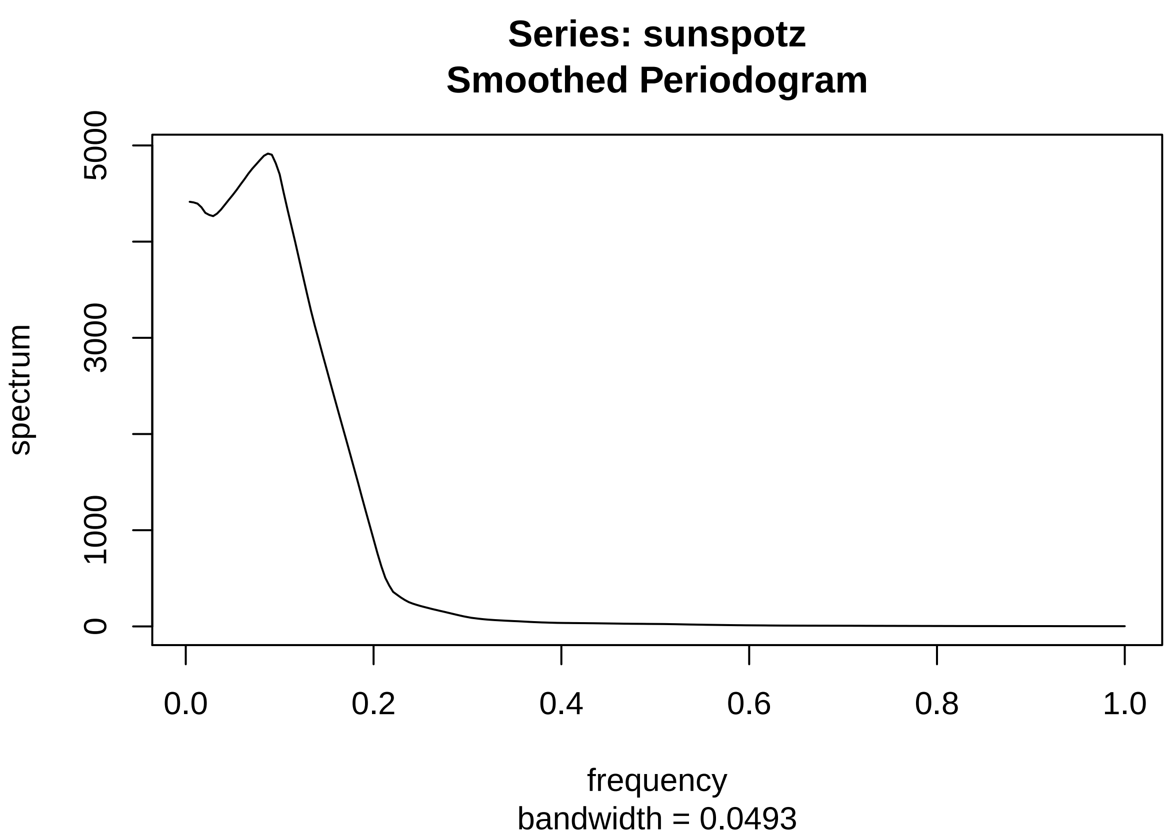
The confidence interval for period 22 is (8804.265,1282807). That for period 20 is (8290.672,1207975). That for period 160 is (3428.087,499482.4).

Question4

```
k=kernel("daniell",c(7,7))
l=kernel("daniell",c(14,14))
ave_1= spec.pgram(sunspotz, k, taper=0, log="no")
```




```
ave_2= spec.pgram(sunspotz, l, taper=0, log="no")
```



```r
1/(which.max(ave_1$spec)/ave_1$n.used)
```

```
## [1] 21.81818
```

```r
1/(which.max(ave_2$spec)/ave_2$n.used)
```

```
## [1] 22.85714
```

When spans=c(7,7), the predominant period is 22. When spans=c(14,14), the predominant period is 23.

```r
 df_1 = ave_1$df
 U_1 = qchisq(.025,df_1)
 L_1 = qchisq(.975,df_1)
df_1*ave_1$spec[22]/L_1
```

```
## [1] 5076.224
```

```r
df_1*ave_1$spec[22]/U_1
```

```
## [1] 11945.4
```

Confidence interval when spans=c(7,7) is (5076.224,11945.4).

```r
 df_2 = ave_2$df
 U_2 = qchisq(.025,df_2)
 L_2 = qchisq(.975,df_2)
df_2*ave_2$spec[21]/L_2
```

```
## [1] 3706.613
```

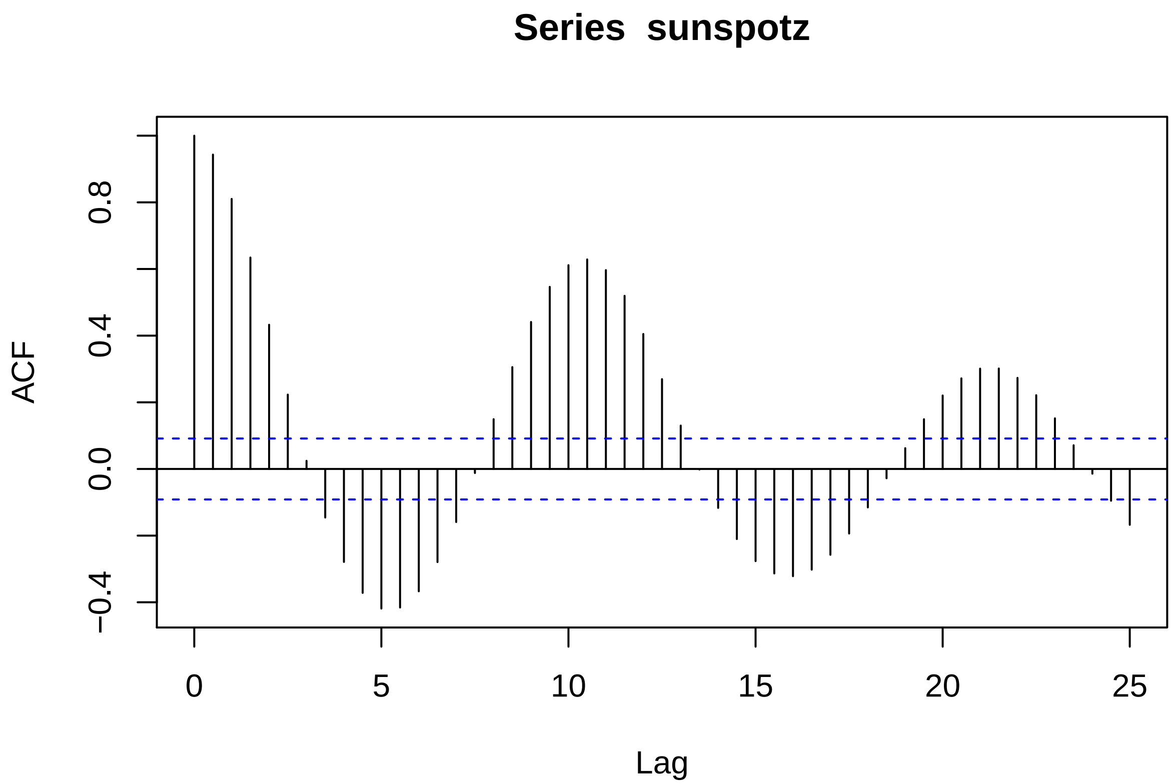
```r
df_2*ave_2$spec[21]/U_2
```

```
## [1] 6832.477
```

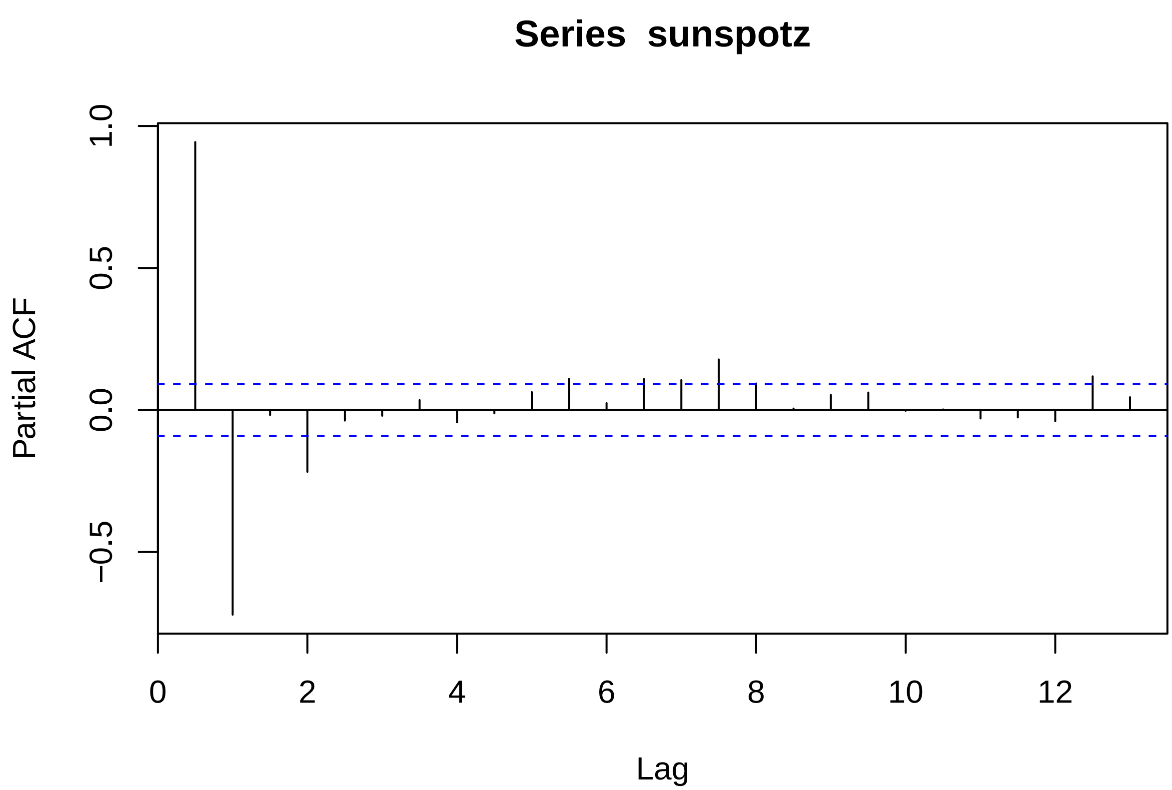
Confidence interval when spans=c(14,14) is (3706.613,6832.477). Spectral estimate is geting smoother and smoother as the frequency band is larger.

Question4

```r
acf(sunspotz,lag.max=50)
```




```r
pacf(sunspotz)
```



The ACF and PACF shows that this model is AR(2).

```r
rec.ML<-arima(sunspotz,order=c(2,0,0),method="ML")
rec.ML
```

```
##
## Call:
## arima(x = sunspotz, order = c(2, 0, 0), method = "ML")
##
## Coefficients:
##          ar1      ar2  intercept
##       1.6941  -0.7876    50.3961
## s.e.  0.0287   0.0288     3.8785
##
## sigma^2 estimated as 60.69:  log likelihood = -1595.68,  aic = 3199.36
```

This is the estimation of coefficients of AR(2).

```r
armaspec=function(T=5000,arcoeff,macoeff,vare){

## Input
## T = resolution in frequency (length of time series)
## arcoeff = vector of coefficients of the AR component of the time series
## macoeff = vector of coefficients of the MA component
## vare = variance of the white noise error

## Output
## specout = spectrum of the ARMA process defined from (0, pi]

## Note: This is the parameterization of the ARMA(p,q) process
## that I will adopt in this program
## X(t) = arcoeff[1]X(t-1) + ... + arcoeff[p]X(t-p) +
## W(t) + macoeff[1]W(t-1) + ... + macoeff[q]W(t-q)
## I will assume that the process is already causal and
## invertible, i.e., the user has done these checks before
## attempting to derive the spectrum.

freq = 2*pi*seq(0, T-1)/T;

arcoeff = c(1, -arcoeff);
macoeff = c(1, macoeff);

theta=c(1:T); phi=c(1:T);

for (k in 1:(T)){

theta.temp=0;
for (m in 1: (length(macoeff)))
{
theta.temp = theta.temp + macoeff[m]*complex(mod=1, arg=-1*m*freq[k])}
theta[k] = (abs(theta.temp))^2

phi.temp=0;
for (m in 1: (length(arcoeff))){
phi.temp = phi.temp + arcoeff[m]*complex(mod=1, arg=-1*m*freq[k])}
phi[k] = (abs(phi.temp))^2
```

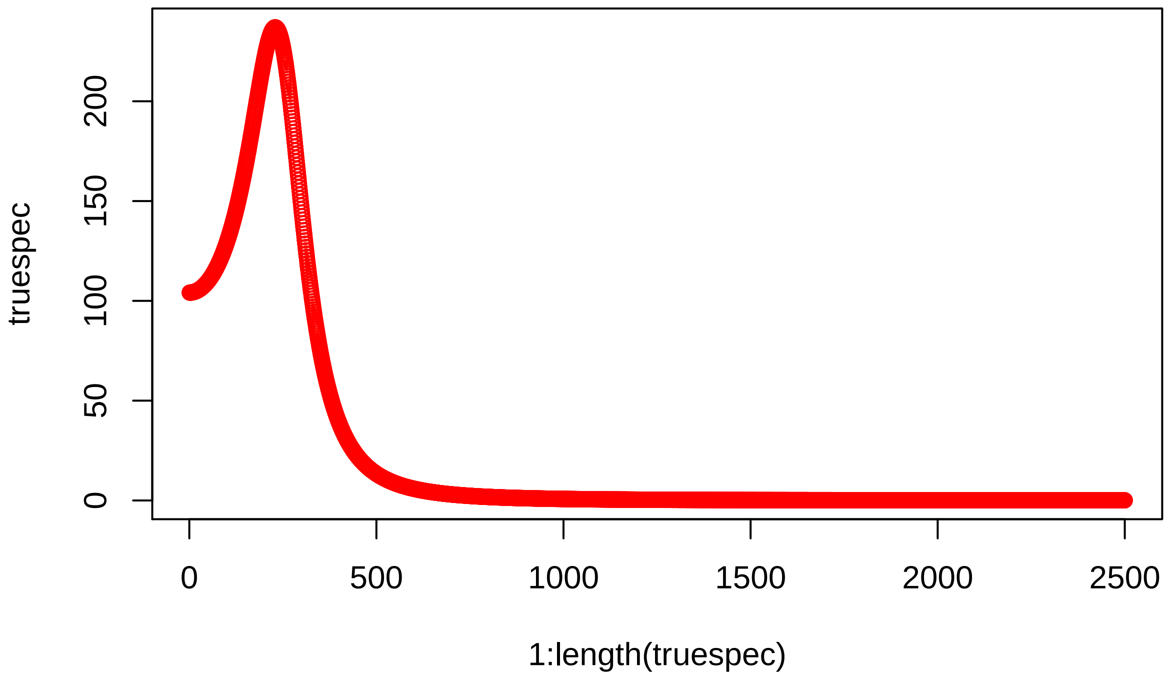
```r
}

spec = vare*(theta)/(phi)
specout = spec[2:(T/2 + 1)]
return(specout)
}
```

```r
truespec=armaspec(arcoeff=c(1.69,-0.788), macoeff=c(0), vare=1)
1/(which.max(truespec)/length(truespec))
```

```
## [1] 10.86957
```

The main periodicity is 11.

```r
plot(1:length(truespec),truespec,col=2)
```



Autoregressive spectral estimator is much smoother than the conventional nonparametric estimator but the distribution is alike.