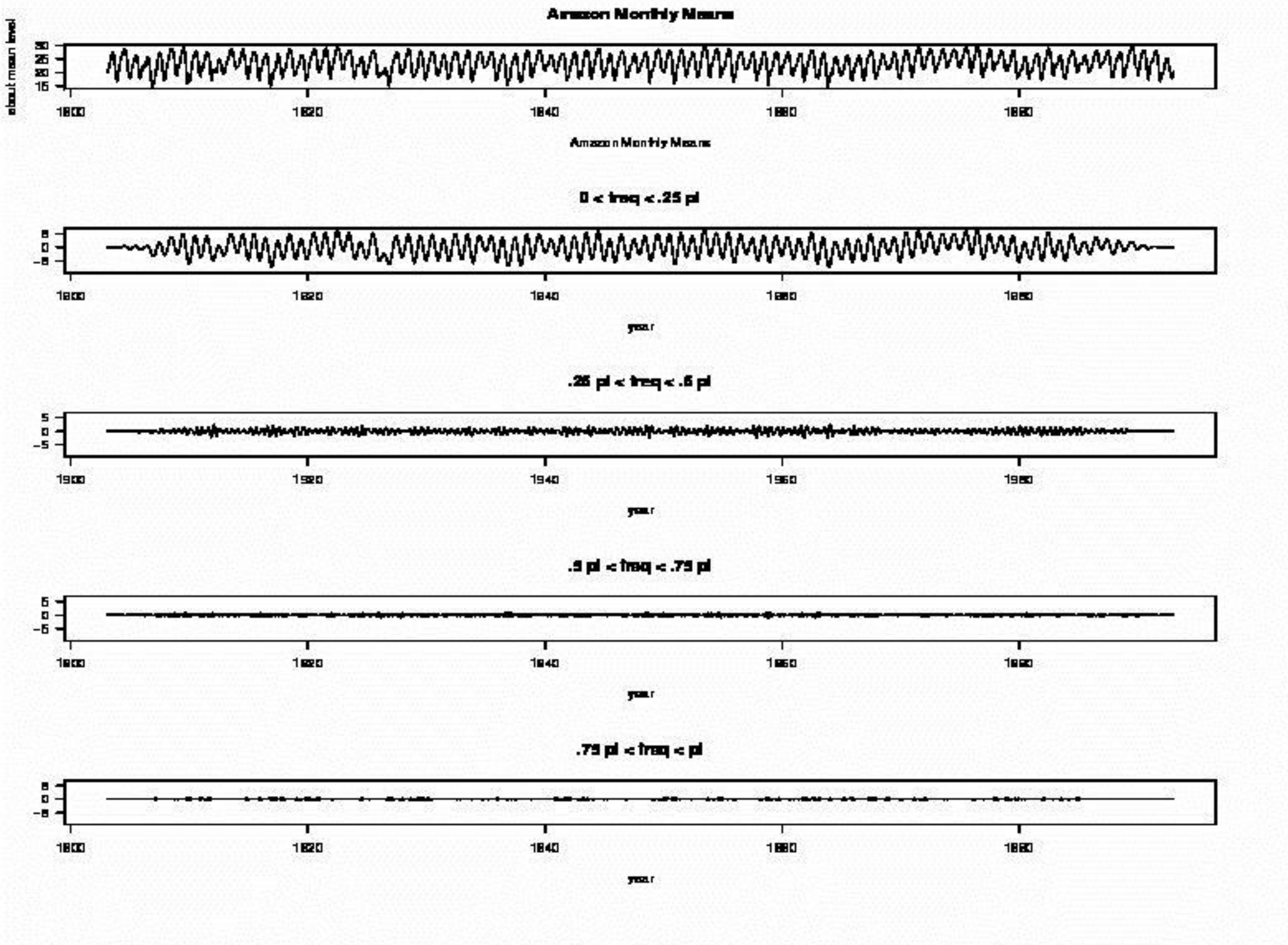
A bank of band-pass filters



```
par(mfrow=c(5,1))
junk<-scan("2003/bymonths"); taxis<-1903+c(1:1080)/12
plot(taxis,junk,main="Amazon Monthly Means",xlab="Amazon Monthly
Means",ylab="about mean
level",type="l",las=1,ylim=c(min(junk),max(junk)))
junkl<-length(junk); junk<-junk-mean(junk)
junk1<-c(spec.taper(junk),rep(0,2048-junkl))
junk2<-fft(junk1); OMEGA<-.25*pi
junkf<-2*pi*c(0:2047)/2048; junk3<-junk2
junk3[junkf>OMEGA&junkf<2*pi-OMEGA]<-0
junk4<-fft(junk3,inv=T)/2048
plot(taxis,Re(junk4[1:junkl]),main="0 < freq <
.25pi",xlab="year",ylab="",type="l",las=1,ylim=c(min(junk),max(junk)))
junk3<-junk2
junk3[junkf>2*OMEGA&junkf<2*pi-2*OMEGA]<-0
junk3[junkf<OMEGA|junkf>2*pi-OMEGA]<-0
junk4<-fft(junk3,inv=T)/2048
```

CONTINUES

```
plot(taxis,Re(junk4[1:junkl]),main=".25 pi < freq
pi",xlab="year",ylab="",type="l",las=1,ylim=c(min(junk),max(junk)))
junk3<-junk2
junk3[junkf>3*OMEGA&junkf<2*pi-3*OMEGA]<-0
junk3[junkf<2*OMEGA|junkf>2*pi-2*OMEGA]<-0
junk4<-fft(junk3,inv=T)/2048
plot(taxis,Re(junk4[1:junkl]),main=".5 pi < freq <
pi",xlab="year",ylab="",type="l",las=1,ylim=c(min(junk),max(junk)))
junk3<-junk2
junk3[junkf<3*OMEGA|junkf>2*pi-3*OMEGA]<-0
junk4<-fft(junk3,inv=T)/2048
plot(taxis,Re(junk4[1:junkl]),main=".75 pi < freq
pi",xlab="year",ylab="",type="l",las=1,ylim=c(min(junk),max(junk)))
```

Complex demodulation

In complex demodulation we first form the pair of real-valued series

$$Y_1(t) = \cos \lambda_0 t \, X(t)$$
$$Y_2(t) = \sin \lambda_0 t \, X(t) \tag{2.7.31}$$

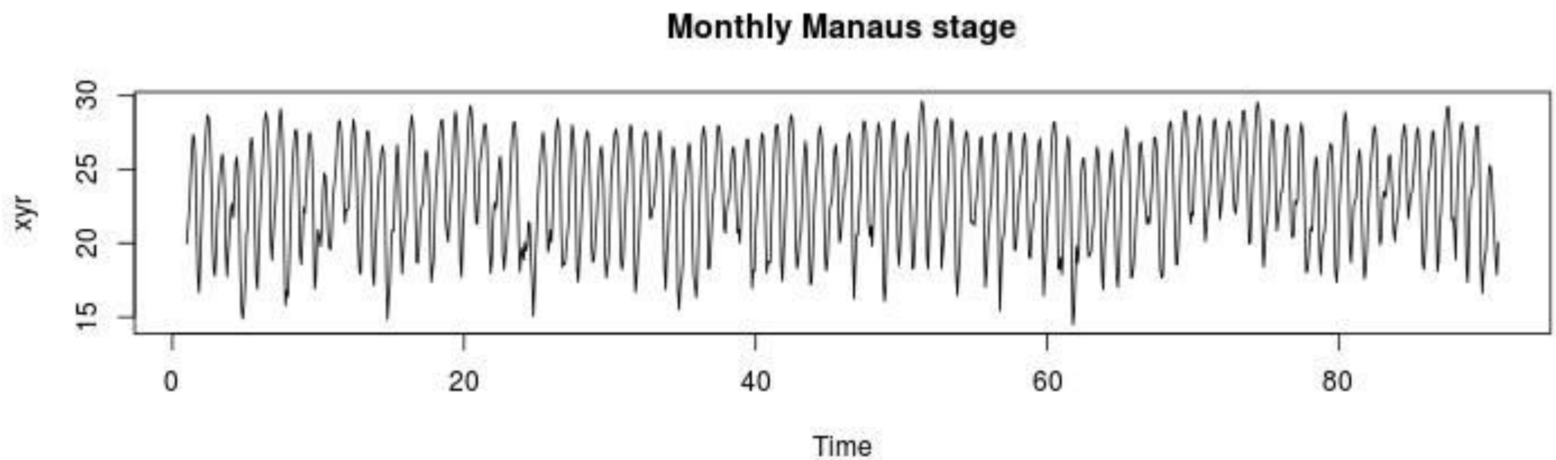
for $t = 0, \pm 1, \ldots$ and then the pair of series

$$W_1(t) = \sum_u a(t-u) Y_1(u)$$
$$W_2(t) = \sum_u a(t-u) Y_2(u) \tag{2.7.32}$$

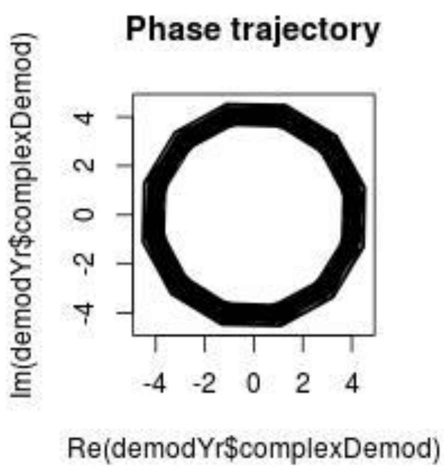
where $\{a(t)\}$ is a low-pass filter. The series, $W_1(t)$, $W_2(t)$ $-\infty < t < \infty$, are called the **complex demodulates** of the series $X(t)$, $-\infty < t < \infty$. Because $\{a(t)\}$ is a low-pass filter, they will typically be substantially smoother than the series $X(t)$, $-\infty < t < \infty$. If we further form the series

$$V_1(t) = \cos \lambda_0 t \, W_1(t) + \sin \lambda_0 t \, W_2(t)$$
$$V_2(t) = \sin \lambda_0 t \, W_1(t) - \cos \lambda_0 t \, W_2(t) \tag{2.7.33}$$

for $-\infty < t < \infty$, then the following lemma shows that the series $V_1(t)$ is essentially a band-pass filtered version of the series $X(t)$, while the series $V_2(t)$ is essentially a band-pass filtered version of the series $X^H(t)$.

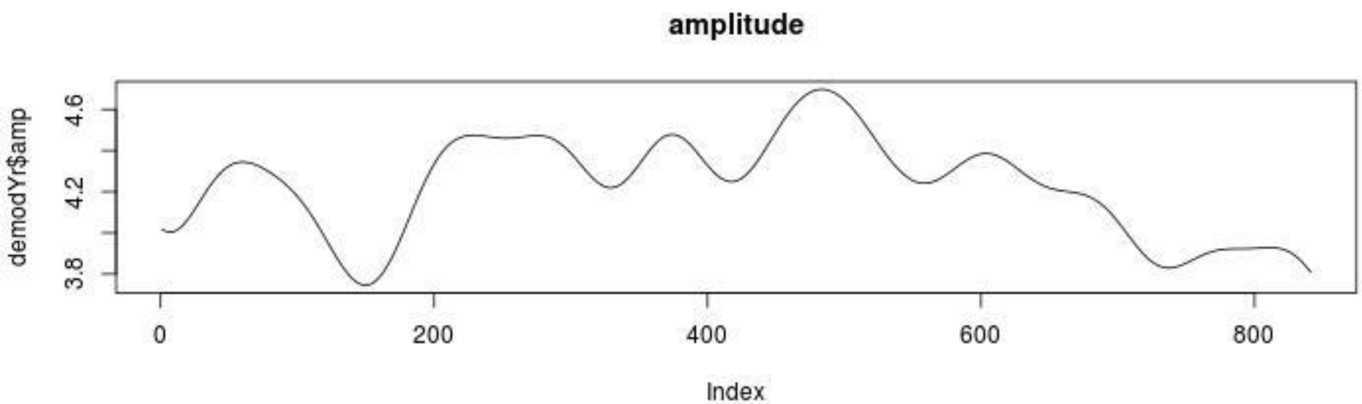


Monthly Manaus stage
xyr
15
20
25
30
0
20
40
60
80
Time

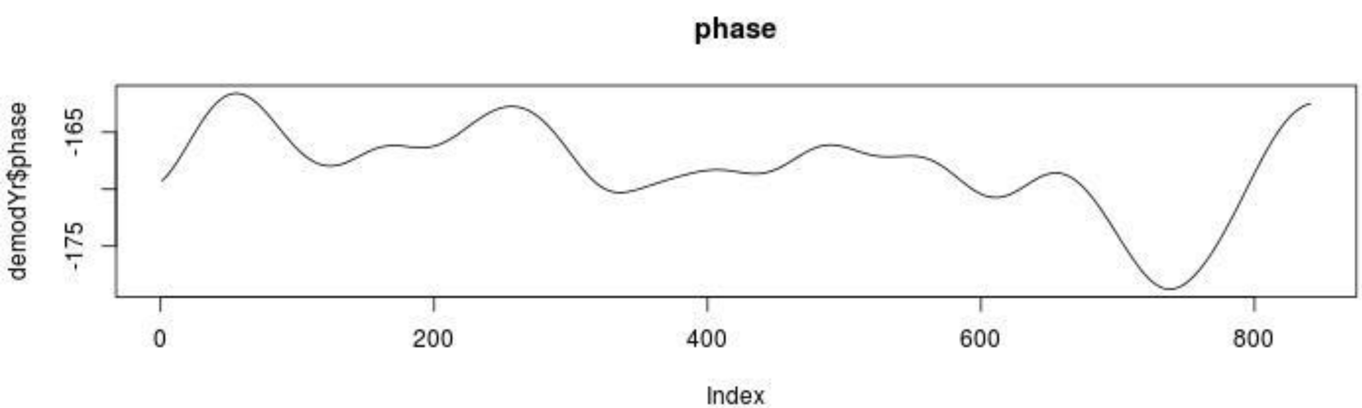


Phase trajectory
Im(demodYr$complexDemod)
-4
-2
0
2
4
-4
-2
0
2
4
Re(demodYr$complexDemod)

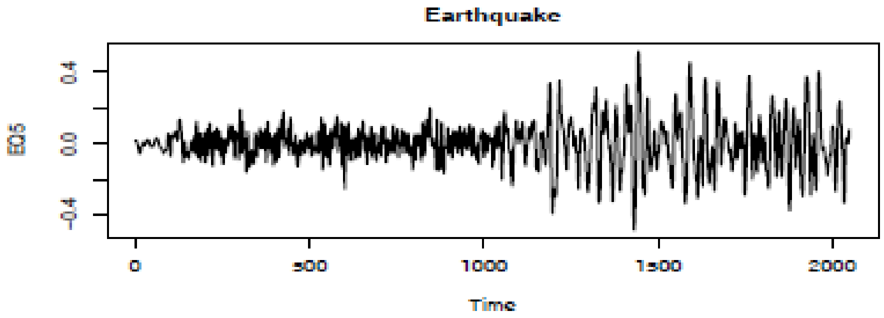
amplitude



phase



The spectrogram/dynamic spectrum analysis.



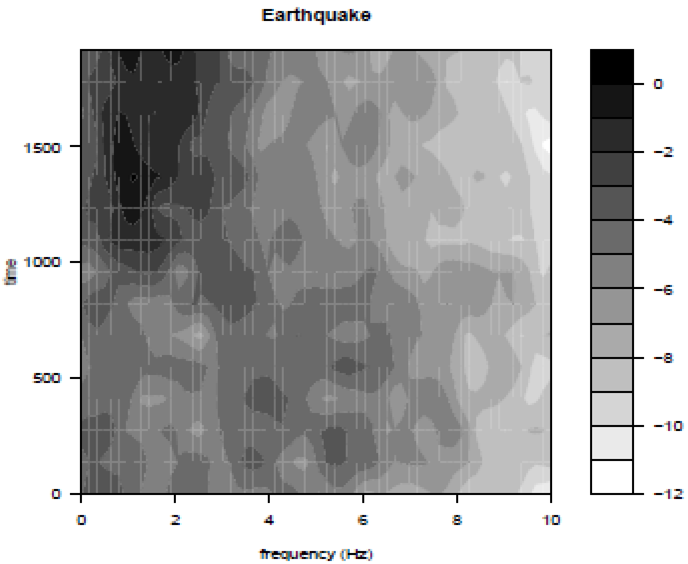
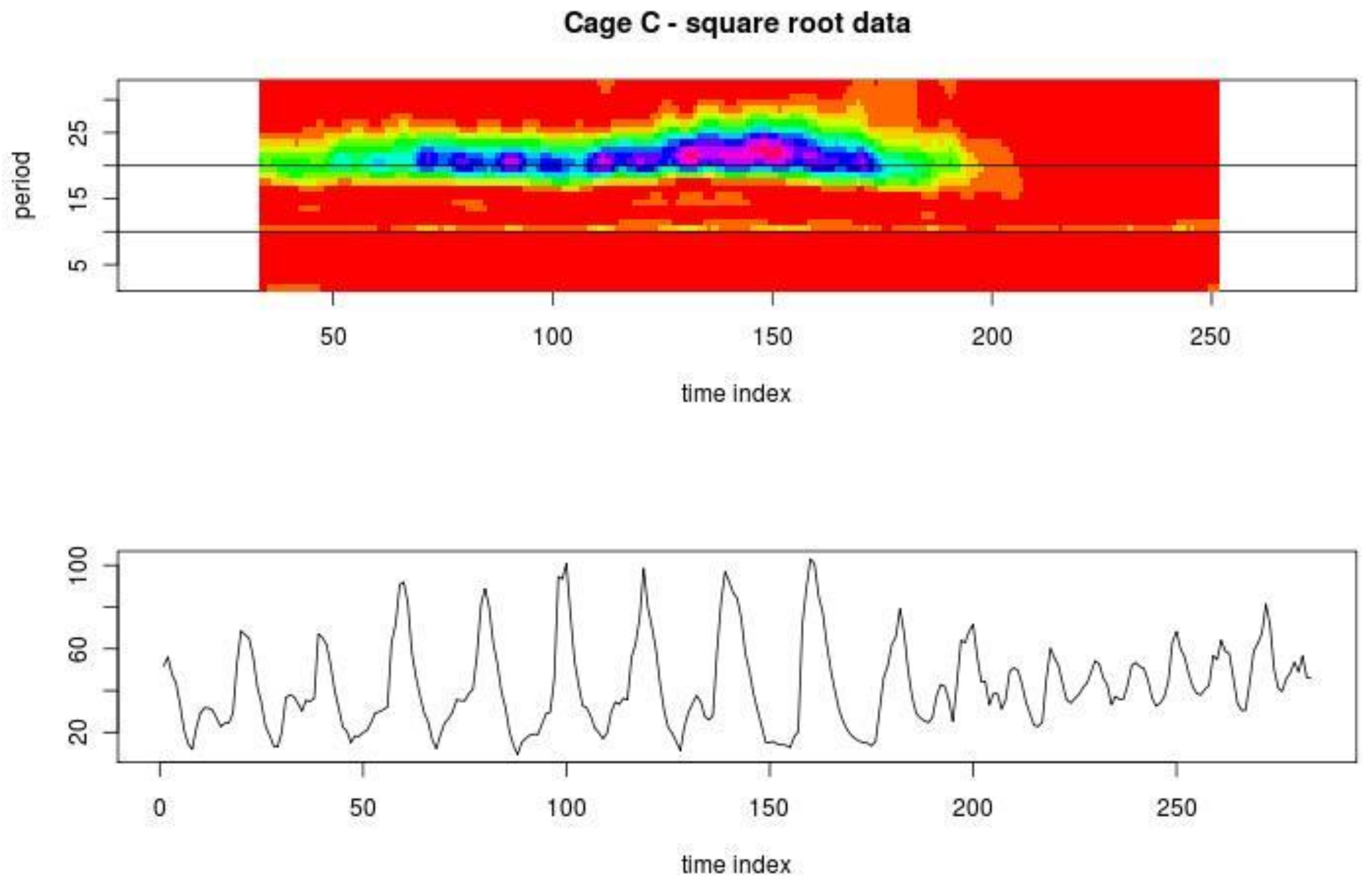


Fig. 4.17. Time-frequency image for the dynamic Fourier analysis of the earthquake series shown in Figure 1.7.

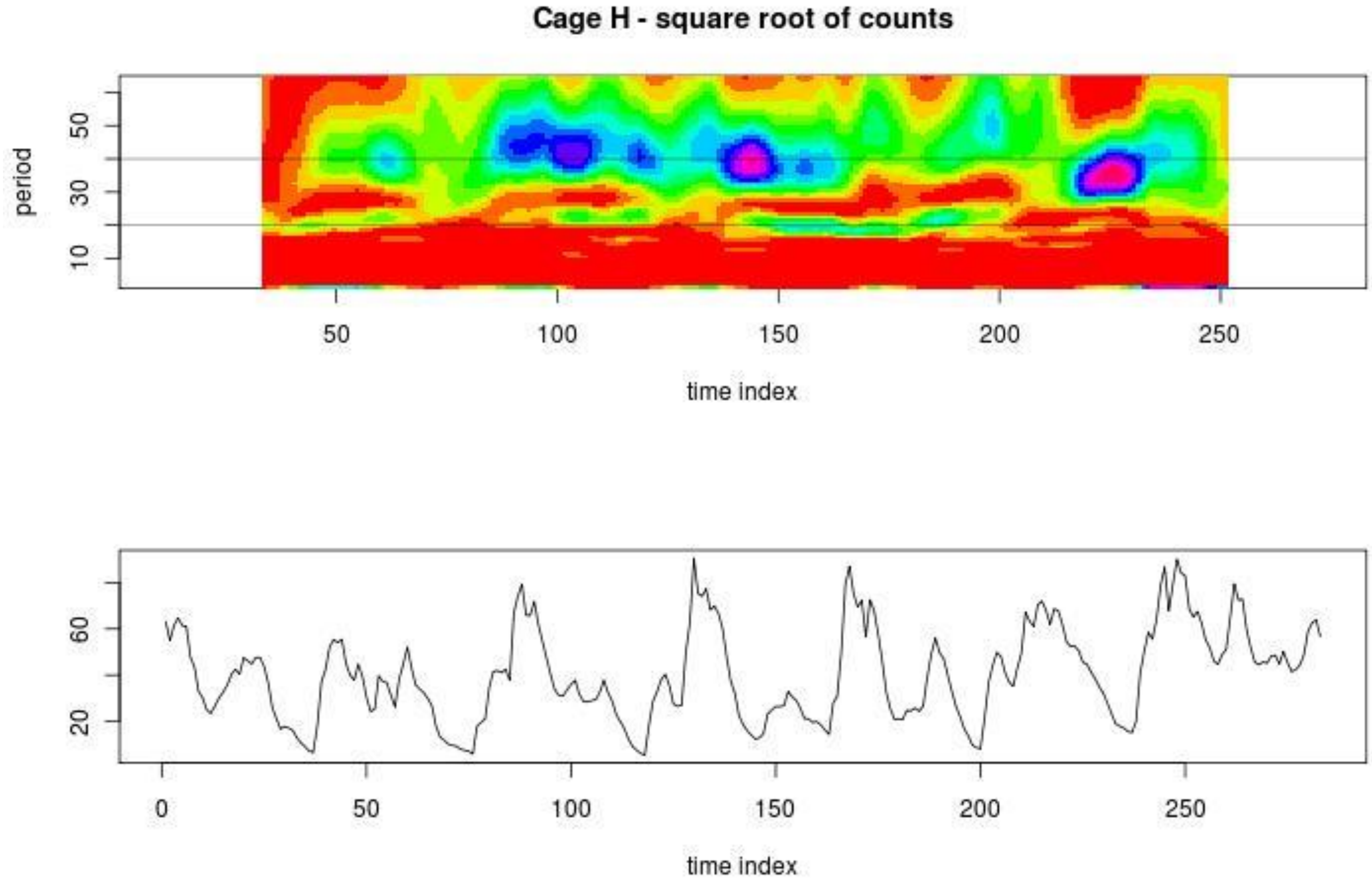
```
nobs = length(EXP6)  # number of observations
wsize = 256   # window size
overlap = 128  # overlap
ovr = wsize-overlap
nseg = floor(nobs/ovr)-1;  # number of segments
krnl = kernel("daniell", c(1,1))  # kernel
ex.spec = matrix(0, wsize/2, nseg)
 for (k in 1:nseg) {
  a = ovr*(k-1)+1
  b = wsize+ovr*(k-1)
  ex.spec[,k] = spectrum(EXP6[a:b], krnl, taper=.5, plot=F)$spec }
x = seq(0, 10,  len = nrow(ex.spec)/2)
y = seq(0, ovr*nseg, len = ncol(ex.spec))
z = ex.spec[1:(nrow(ex.spec)/2),]
filled.contour(x , y, log(z), ylab="time",xlab="frequency (Hz)",
     nlevels=12, col=gray(11:0/11), main="Explosion")
persp(x, y, z, zlab="Power",xlab="frequency (Hz)",ylab="time",
     ticktype="detailed", theta=25,d=2, main="Explosion")  # not shown
```

Nicholson’s blowfly experiments

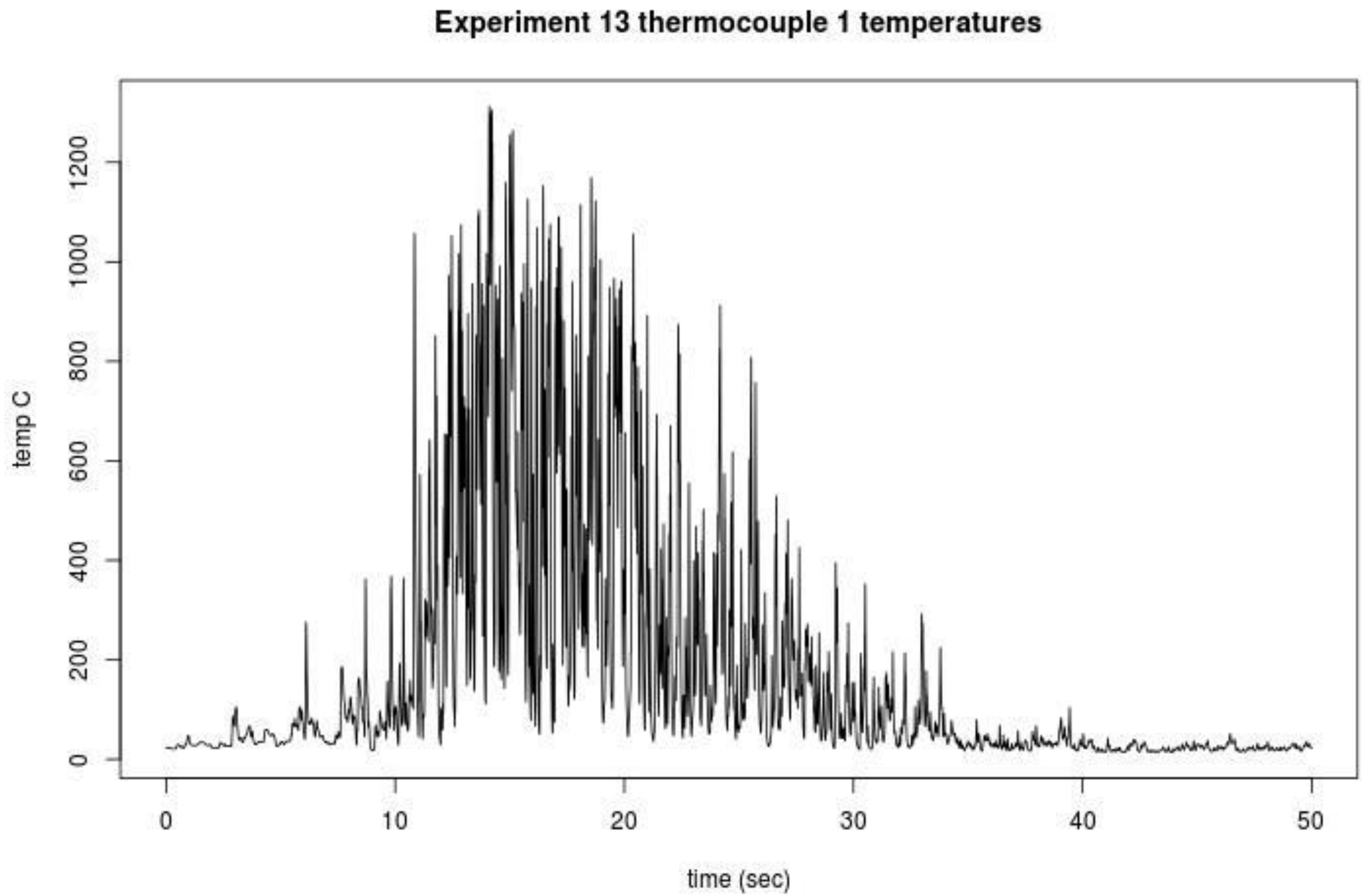
Cage C.   Known period 20 (Near natural period)   lines at 10,20



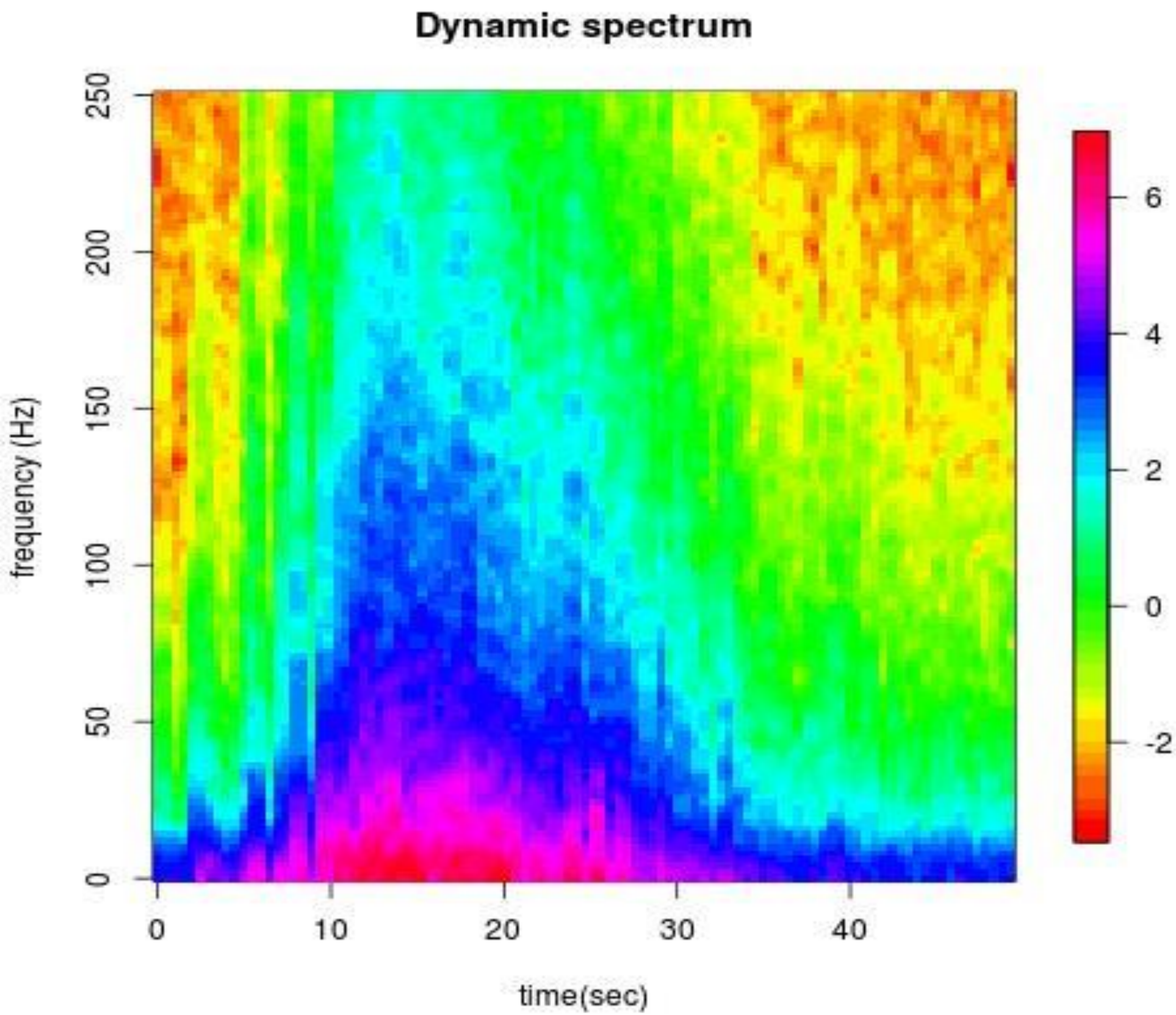
Cage H. Known period 40 Square root {counts)



USFS experimental fire



Experiment 13 thermocouple 1 temperatures
temp C
0
200
400
600
800
1000
1200
0
10
20
30
40
50
time (sec)



Dynamic spectrum
250
200
150
100
50
0
frequency (Hz)
0
10
20
30
40
time(sec)
6
4
2
0
-2