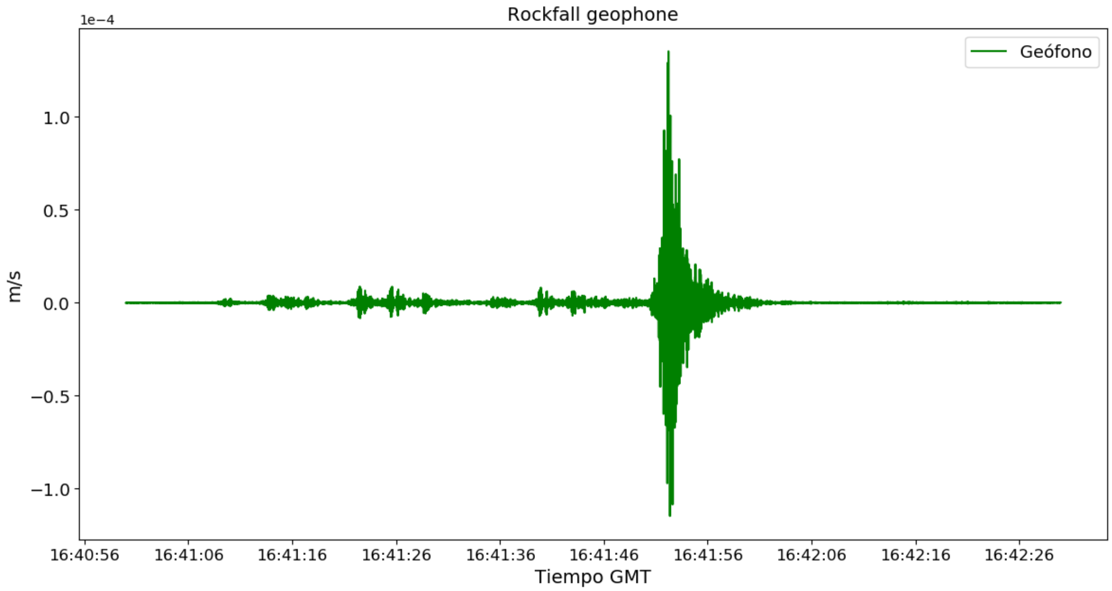
Rockfall, Montegrande ravine

May 14, 2018

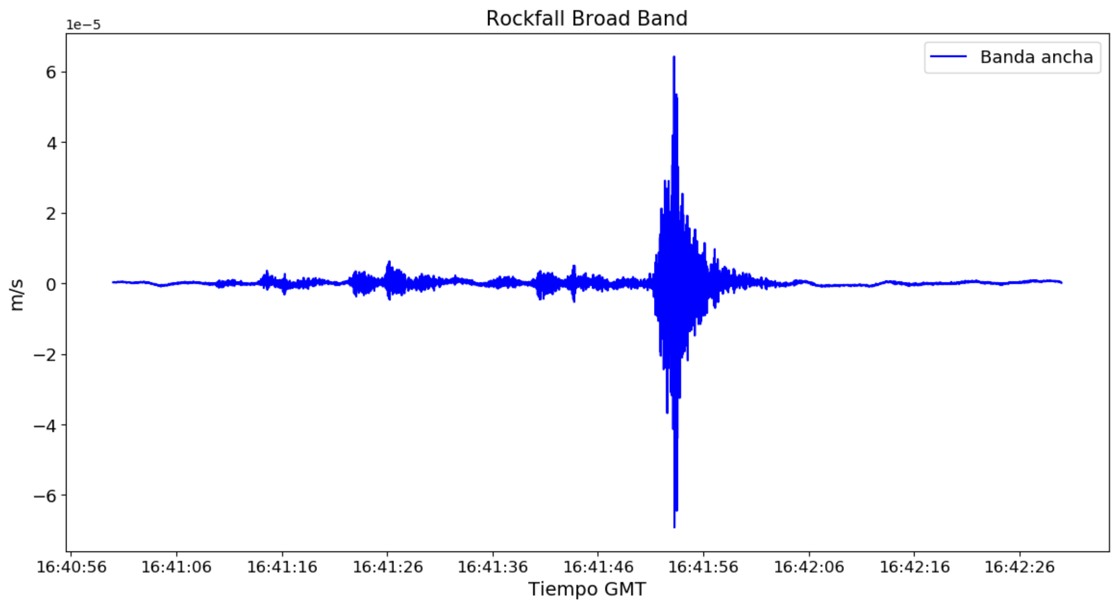
0.0.1 Libreta de *Jupyter* donde se desarrolla el análisis sísmico del experimento de caída de roca en la barranca Montegrande, Volcán de Colima, que se presentó en el IX Congreso Nacional de Estudiantes de Ciencias de la Tierra bajo el título: *"Caracterización tiempo-frecuencia de la señal sísmica generada por una caída de roca en la barranca Montegrande, Volcán de Colima"*.

```
In [1]: using DSP
        using SAC
        using PyPlot

In [2]: bb = SAC.read("BBRockFall.sac");
        geo = SAC.read("GeoRockFall.sac");

INFO: Data are little-endian; byteswappingINFO: Data are little-endian; byteswapping

In [3]: bb.t = bb.t*(410.744e-12);
        geo.t = geo.t*(3.125e-8);

In [4]: ti = (DateTime(2017,11,6,16,41,0):(Dates.Millisecond(1))*10:DateTime(2017,11,6,16,42,30)

In [5]: ds1 = 1/(geo.delta*geo.npts);
        ds2 = 1/(bb.delta*bb.npts);

In [6]: fg = collect(0:geo.npts-1)*ds1;
        n1 = convert(Int32,floor(geo.npts/2)+1);
        fb = collect(0:bb.npts-1)*ds2;
        n2 = convert(Int32,floor(bb.npts/2)+1);

In [7]: rmean!(geo);
        rtrend!(geo);
        rmean!(bb);
        rtrend!(bb);

In [9]: fig = figure(figsize=(14,7))
        plot(ti,geo.t, label = "Geófono", "g")
        #ax=gca()
        title("Rockfall geophone", fontsize=14)
        xlabel("Tiempo GMT", fontsize=14)
        xticks(fontsize=12)
```

```
#ax[:ticklabel_format](format="sci",axis="y",scilimits=(0,0))
ticklabel_format(format="sci",axis="y",scilimits=(0,0))
ylabel("m/s", fontsize=14)
yticks(fontsize=13)
legend(loc="best",fontsize=13)
PyPlot.savefig("gt.png",dpi=500)
```




```
In [10]: fig = figure(figsize=(14,7))
         plot(ti,bb.t,label="Banda ancha","b")
         title("Rockfall Broad Band", fontsize=15)
         xlabel("Tiempo GMT", fontsize=14)
         xticks(fontsize=12)
         ticklabel_format(format="sci",axis="y",scilimits=(0,0))
         ylabel("m/s", fontsize=14)
         yticks(fontsize=13)
         legend(loc="best",fontsize=13)
         PyPlot.savefig("bt.png",dpi=500)
```



0.1 *fft*

```
In [8]: fou = abs.(fft(geo.t,1));
        fou2 = fou.^2;
        fou3 = fou2.*2;
        fgn = fou3./100;
        fgnr = fgn./maximum(fgn);
```

0.2 Filtro Butterworth pasa-bandas BB: 1-49 Hz

```
In [11]: bbr = Bandpass(1,49,fs=100)
         desig = Butterworth(4)
         fil = filt(digitalfilter(bbr,desig),bb.t);

In [12]: filb = abs.(fft(fil,1));
         filbn = filb./maximum(filb);

In [13]: filb2 = filb.^2;
         filb3 = filb2.*2;
         ffbn = filb3./100;
```

0.3 Método de Welch

```
In [14]: w = welch_pgram(geo.t,fs=100);
         wn = w.power/maximum(w.power);

In [15]: wfil = welch_pgram(fil,fs=100);
         wfiln = wfil.power/maximum(wfil.power);
```

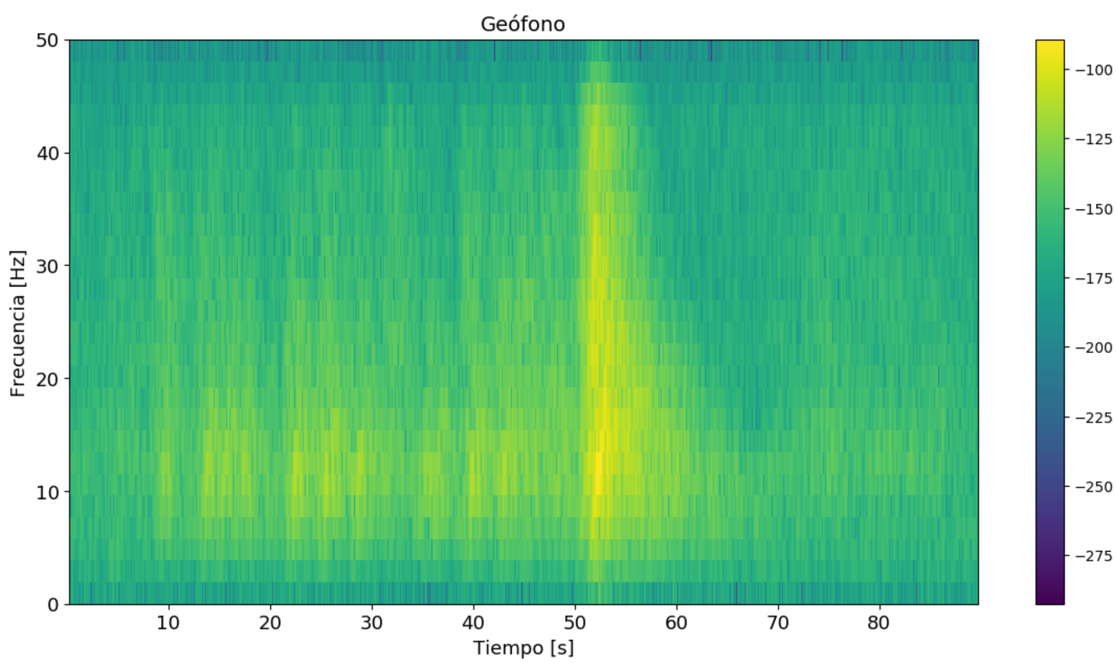
0.4 Multitaper

```
In [16]: mt = mt_pgram(geo.t,fs=100);
         mtn = mt.power/maximum(mt.power);
```

```
In [17]: mtbf = mt_pgram(fil,fs=100);
         mtbfn = mtbf.power/maximum(mtbf.power);
```

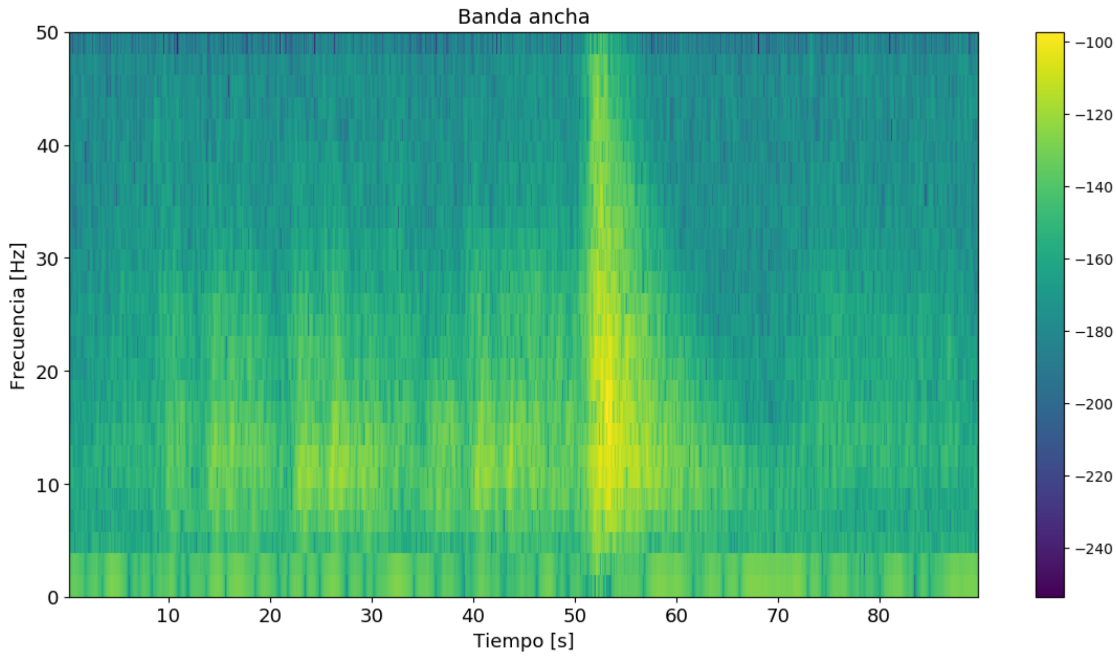
0.5 Espectrogramas

```
In [18]: #Geófono
         fig = figure(figsize=(14,7))
         specgram(geo.t,50,100,pad_to=50,noverlap=49)
         title("Geófono", fontsize=14)
         xlabel("Tiempo [s]", fontsize=13)
         xticks(fontsize=13)
         ylabel("Frecuencia [Hz]", fontsize=13)
         yticks(fontsize=13)
         PyPlot.colorbar()
         #(mappable=None, cax=None, ax=None, grays)
         PyPlot.savefig("spec_g.png", dpi=500)
```




```
In [19]: #Banda ancha
         fig = figure(figsize=(14,7))
         specgram(bb.t,50,100,pad_to=50,noverlap=49)
         title("Banda ancha", fontsize=14)
```

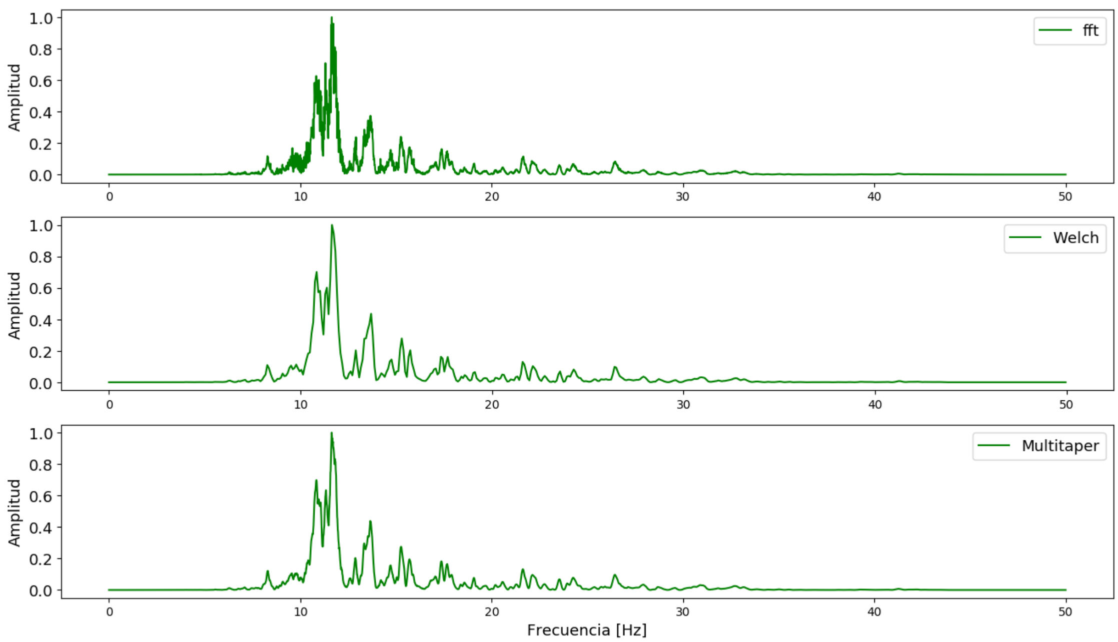
```
xlabel("Tiempo [s]", fontsize=13)
xticks(fontsize=13)
ylabel("Frecuencia [Hz]", fontsize=13)
yticks(fontsize=13)
colorbar()
PyPlot.savefig("spec_bb.png",dpi=500)
```



0.6 3 Métodos Geófono

```
In [20]: fig = figure(figsize=(16,9))
         subplot(3,1,1)
         plot(fg[1:n1],fgnr[1:n1], label="fft","g")
         #title("fft", fontsize=15)
         #xlabel("Frecuencia [Hz]",fontsize=13)
         xticks(fontsize=10)
         ticklabel_format(format="sci",axis="y",scilimits=(0,0))
         ylabel("Amplitud",fontsize=13)
         yticks(fontsize=13)
         legend(loc="best", fontsize=13)
         subplot(3,1,2)
         plot(w.freq,wn, "g", label="Welch")
         #title("Welch", fontsize=14)
         #xlabel("Frecuencia [Hz]", fontsize=13)
         xticks(fontsize=10)
         ticklabel_format(format="sci",axis="y")
         #,scilimits=(0,0))
```

```
ylabel("Amplitud", fontsize=13)
yticks(fontsize=13)
legend(loc="best", fontsize=13)
subplot(3,1,3)
plot(mt.freq,mtn,label="Multitaper", "g")
#title("Multitaper", fontsize=14)
xlabel("Frecuencia [Hz]",fontsize=13)
xticks(fontsize=10)
ticklabel_format(format="sci",axis="y")
#,scilimits=(0,0))
ylabel("Amplitud", fontsize=13)
yticks(fontsize=13)
legend(loc="best", fontsize=13)
PyPlot.savefig("3s_geo.png",dpi=500)
```



0.7 3 Métodos Banda ancha

```
In [21]: fig = figure(figsize=(16,9))
         subplot(3,1,1)
         plot(fb[1:n1],filbn[1:n1], label="fft" ,"b")
         #title("fft", fontsize=14)
         #xlabel("Frecuencia [Hz]", fontsize=13)
         xticks(fontsize=10)
         ticklabel_format(format="sci",axis="y",scilimits=(0,0))
         ylabel("Amplitud", fontsize=13)
         yticks(fontsize=13)
```

```
legend(loc="best", fontsize=13)
subplot(3,1,2)
plot(wfil.freq,wfiln,label="Welch" ,"b")
#title("Welch", fontsize=14)
#xlabel("Frecuencia [Hz]", fontsize=13)
xticks(fontsize=10)
ylabel("Amplitud", fontsize=13)
yticks(fontsize=13)
legend(loc="best", fontsize=13)
subplot(3,1,3)
plot(mtbf.freq,mtbfn,label="Multitaper","b")
#title("Multitaper", fontsize=14)
xlabel("Frecuencia [Hz]", fontsize=13)
xticks(fontsize=10)
ylabel("Amplitud", fontsize=13)
yticks(fontsize=13)
legend(loc="best", fontsize=13)
PyPlot.savefig("3s_bb.png",dpi=500)
```