analisis_sismos

October 6, 2024

#

Script de analisis

0.1 Importacion de librerias

[57]:
```
import numpy as np
import pandas as pd
from obspy import read
from datetime import datetime, timedelta
import matplotlib.pyplot as plt
import os
```

0.2 Catalogo de sismos para entrenamiento

[58]:
```
cat_directory = './data/lunar/training/catalogs/'
cat_file=cat_directory+'apollo12_catalog_GradeA_final.csv'
cat = pd.read_csv(cat_file)
cat
```

[58]:
```
                                   filename time_abs(%Y-%m-%dT%H:%M:%S.%f)  \
0   xa.s12.00.mhz.1970-01-19HR00_evid00002     1970-01-19T20:25:00.000000
1   xa.s12.00.mhz.1970-03-25HR00_evid00003     1970-03-25T03:32:00.000000
2   xa.s12.00.mhz.1970-03-26HR00_evid00004     1970-03-26T20:17:00.000000
3   xa.s12.00.mhz.1970-04-25HR00_evid00006     1970-04-25T01:14:00.000000
4   xa.s12.00.mhz.1970-04-26HR00_evid00007     1970-04-26T14:29:00.000000
..                                      …                            …
71  xa.s12.00.mhz.1974-10-14HR00_evid00156     1974-10-14T17:43:00.000000
72  xa.s12.00.mhz.1975-04-12HR00_evid00191     1975-04-12T18:15:00.000000
73  xa.s12.00.mhz.1975-05-04HR00_evid00192     1975-05-04T10:05:00.000000
74  xa.s12.00.mhz.1975-06-24HR00_evid00196     1975-06-24T16:03:00.000000
75  xa.s12.00.mhz.1975-06-26HR00_evid00198     1975-06-26T03:24:00.000000

    time_rel(sec)       evid    mq_type
0         73500.0  evid00002  impact_mq
1         12720.0  evid00003  impact_mq
2         73020.0  evid00004  impact_mq
3          4440.0  evid00006  impact_mq
```

```
4         52140.0  evid00007    deep_mq
..            …         …        …
71        63780.0  evid00156  impact_mq
72        65700.0  evid00191  impact_mq
73        36300.0  evid00192  impact_mq
74        57780.0  evid00196  impact_mq
75        12240.0  evid00198  impact_mq

[76 rows x 5 columns]
```

0.3 Lectura de tiempos de arribo relativo

[59]:
```python
row = cat.iloc[0]
arrival_time = datetime.strptime(row['time_abs(%Y-%m-%dT%H:%M:%S.
 ↪%f)'],'%Y-%m-%dT%H:%M:%S.%f')
arrival_time
# If we want the value of relative time, we don't need to use datetime
arrival_time_rel = row['time_rel(sec)']
arrival_time_rel
```

[59]:
```
73500.0
```

0.4 Descripcion de datos

[60]:
```python
csv_file = './data/lunar/training/data/S12_GradeA/xa.s12.00.mhz.
 ↪1970-07-20HR00_evid00011.csv'
data_cat = pd.read_csv(csv_file)
data_cat.describe()
```

[60]:
```
       time_rel(sec)  velocity(m/s)
count  572411.000000   5.724110e+05
mean    43200.754717  -5.624328e-13
std     24942.032725   7.318489e-10
min         0.000000  -2.022016e-08
25%     21600.377358  -1.248466e-10
50%     43200.754717  -2.497256e-13
75%     64801.132075   1.182554e-10
max     86401.509434   1.964506e-08
```

0.5 Lectura del frame como serie de tiempo

[61]:
```python
luna=pd.read_csv(csv_file,index_col=0,parse_dates=True)
luna
```

[61]:
```
                                time_rel(sec)  velocity(m/s)
time_abs(%Y-%m-%dT%H:%M:%S.%f)
1970-07-20 00:00:00.487000           0.000000  -1.462155e-15
```

```
1970-07-20 00:00:00.637943          0.150943  -1.824771e-15
1970-07-20 00:00:00.788887          0.301887  -1.974266e-15
1970-07-20 00:00:00.939830          0.452830  -1.886487e-15
1970-07-20 00:00:01.090774          0.603774  -1.646714e-15
…                                        …             …
1970-07-21 00:00:01.392660      86400.905660  -3.375389e-16
1970-07-21 00:00:01.543604      86401.056604  -4.551111e-16
1970-07-21 00:00:01.694547      86401.207547  -5.143100e-16
1970-07-21 00:00:01.845491      86401.358491  -6.834513e-16
1970-07-21 00:00:01.996434      86401.509434  -1.028684e-15

[572411 rows x 2 columns]
```

0.6 Cambio de muestreo de la serie de tiempo (5 mediciones por segundo a 1 segundo por medicion)

[62]:
```python
seg=luna.resample('s').mean()
seg
```

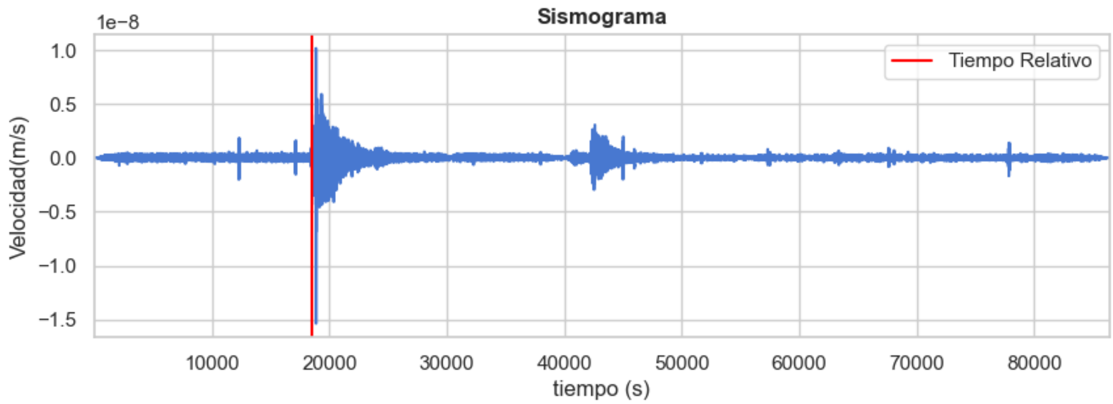
[62]:
```
                                time_rel(sec)  velocity(m/s)
time_abs(%Y-%m-%dT%H:%M:%S.%f)
1970-07-20 00:00:00                  0.226415  -1.786920e-15
1970-07-20 00:00:01                  1.056604  -9.123013e-16
1970-07-20 00:00:02                  2.037736   4.416532e-16
1970-07-20 00:00:03                  3.018868   7.001884e-16
1970-07-20 00:00:04                  4.000000   1.291406e-16
…                                        …             …
1970-07-20 23:59:57              86396.981132  -5.387787e-16
1970-07-20 23:59:58              86398.037736  -6.445551e-16
1970-07-20 23:59:59              86399.018868   5.491000e-16
1970-07-21 00:00:00              86400.000000   1.823867e-15
1970-07-21 00:00:01              86401.056604  -3.514898e-16

[86402 rows x 2 columns]
```

0.7 Graficacion del sismograma

[63]:
```python
# Lectura de velocidades
csv_times = np.array(seg['time_rel(sec)'].tolist())
csv_data = np.array(seg['velocity(m/s)'].tolist())
# Graficacion
fig,ax = plt.subplots(1,1,figsize=(10,3))
ax.plot(csv_times,csv_data)
# elementos de la grafica
ax.grid(True)
ax.set_xlim([min(csv_times),max(csv_times)])
ax.set_ylabel('Velocidad(m/s)')
```

```
ax.set_xlabel('tiempo (s)')
ax.set_title("Sismograma", fontweight='bold')
# Plot where the arrival time is
arrival_line = ax.axvline(x=18500, c='red', label='Tiempo Relativo')
ax.legend(handles=[arrival_line])
```

[63]: <matplotlib.legend.Legend at 0x25a2f2543e0>



[ ]:

[ ]:

##

Analisis mediante frecuencia de la señal

0.8 Lectura de datos de sismografo

[64]:
```
mseed_archivo ='./data/lunar/training/data/S12_GradeA/xa.s12.00.mhz.
↪1970-07-20HR00_evid00011.mseed'
frame_sismo=read(mseed_archivo)
frame_sismo
```

[64]:
```
1 Trace(s) in Stream:
XA.S12.00.MHZ | 1970-07-20T00:00:00.487000Z - 1970-07-21T00:00:01.996434Z | 6.6
Hz, 572411 samples
```

[65]:
```
frame_sismo[0].stats
```

[65]:
```
         network: XA
         station: S12
        location: 00
         channel: MHZ
```

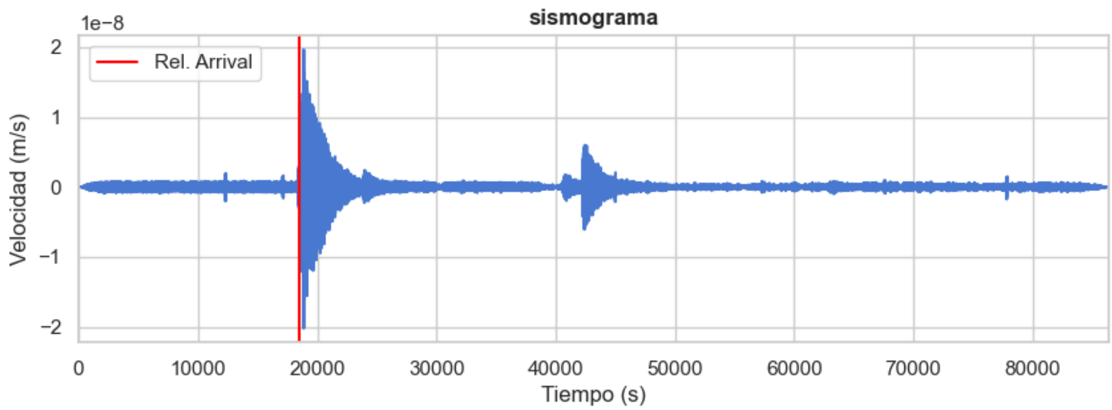
```
        starttime: 1970-07-20T00:00:00.487000Z
          endtime: 1970-07-21T00:00:01.996434Z
    sampling_rate: 6.625
            delta: 0.1509433962264151
             npts: 572411
            calib: 1.0
          _format: MSEED
            mseed: AttribDict({'dataquality': 'D', 'number_of_records': 1136,
'encoding': 'FLOAT64', 'byteorder': '>', 'record_length': 4096, 'filesize':
4653056})
```

[66]:
```
# This is how you get the data and the time, which is in seconds
tr = frame_sismo.traces[0].copy()
tr_times = tr.times()
tr_data = tr.data

# Start time of trace (another way to get the relative arrival time using
 ↪datetime)
starttime = tr.stats.starttime.datetime
arrival = (arrival_time - starttime).total_seconds()
arrival
```

[66]:
```
-15651300.487
```

[67]:
```
# Initialize figure
fig,ax = plt.subplots(1,1,figsize=(10,3))
# Plot trace
ax.plot(tr_times,tr_data)
# Mark detection
ax.axvline(x = 18500, color='red',label='Rel. Arrival')
ax.legend(loc='upper left')
# Make the plot pretty
ax.set_xlim([min(tr_times),max(tr_times)])
ax.set_ylabel('Velocidad (m/s)')
ax.set_xlabel('Tiempo (s)')
ax.set_title("sismograma", fontweight='bold')
```

[67]:
```
Text(0.5, 1.0, 'sismograma')
```



0.9 Filtro por Frecuencia pasa banda (0.01 Hz a 0.5 Hz)

[68]:

```
# Configurando las frecuencias criticas del filtro
minfreq = 0.5
maxfreq = 1.0
# Creando una grafica distinta para el manejo de los datos
st_filt = frame_sismo.copy()
st_filt.filter('bandpass',freqmin=minfreq,freqmax=maxfreq)
tr_filt = st_filt.traces[0].copy()
tr_times_filt = tr_filt.times()
tr_data_filt = tr_filt.data
```

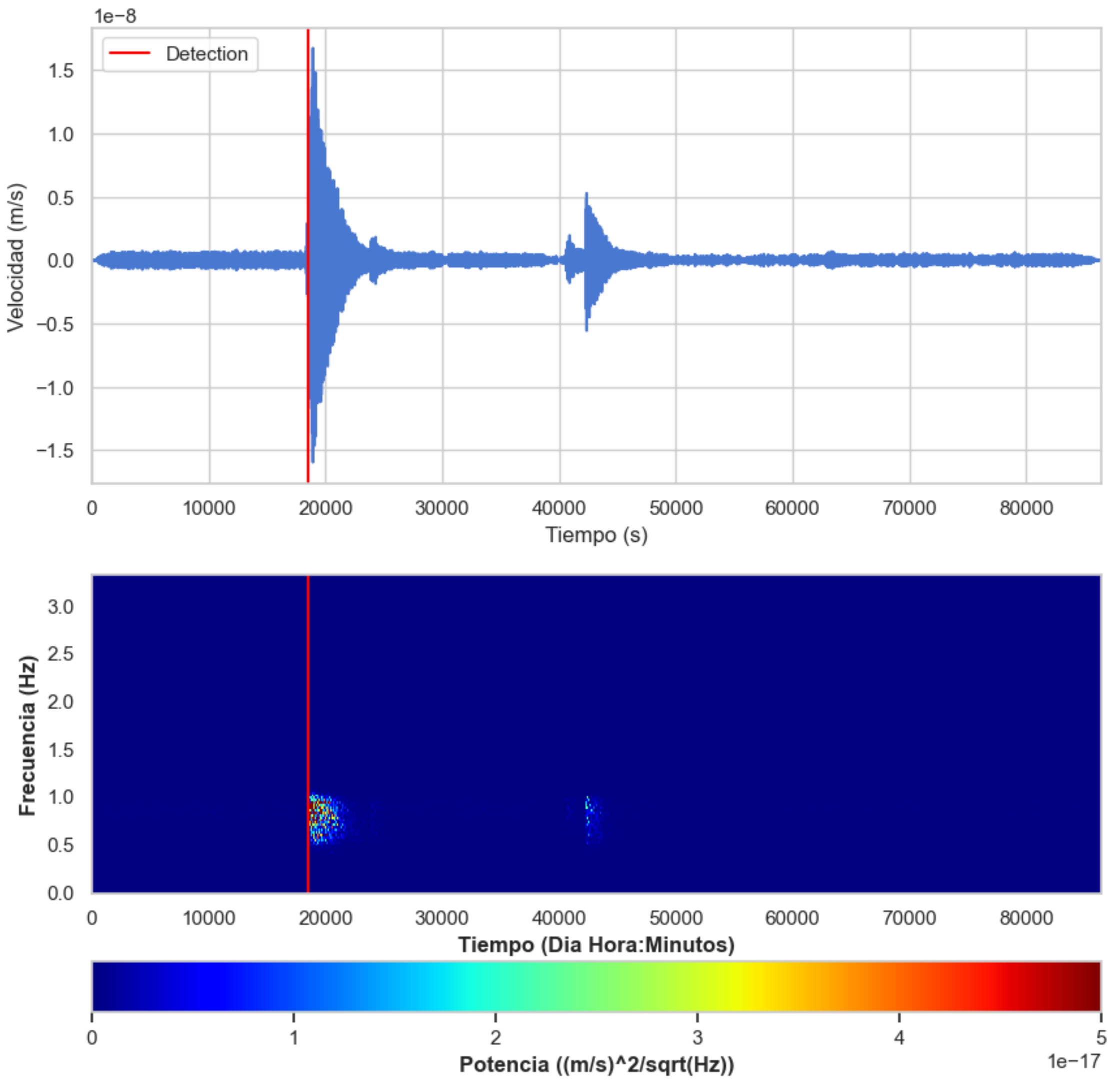
[69]:

```
# para mejorar la visualizacion de los datos, estos pueden un espectograma de␣
↪la funcion de scipy
# Requiere la frecuencia de muestreo, que podemos obtener del encabezado␣
↪miniseed como se muestra en algunas celdas arriba.
from scipy import signal
from matplotlib import cm
f, t, sxx = signal.spectrogram(tr_data_filt, tr_filt.stats.sampling_rate)
```

[70]:

```
# Graficar la serie temporal y el espectrograma
fig = plt.figure(figsize=(10, 10))
ax = plt.subplot(2, 1, 1)
# Traza de la grafica
ax.plot(tr_times_filt,tr_data_filt)
# Marca de deteccion
ax.grid(True)
ax.axvline(x = 18500, color='red',label='Detection')
ax.legend(loc='upper left')
# Mejorando la grafica
ax.set_xlim([min(tr_times_filt),max(tr_times_filt)])
ax.set_ylabel('Velocidad (m/s)')
```

```
ax.set_xlabel('Tiempo (s)')
ax2 = plt.subplot(2, 1, 2)
vals = ax2.pcolormesh(t, f, sxx, cmap=cm.jet, vmax=5e-17)
ax2.set_xlim([min(tr_times_filt),max(tr_times_filt)])
ax2.set_xlabel(f'Tiempo (Dia Hora:Minutos)', fontweight='bold')
ax2.set_ylabel('Frecuencia (Hz)', fontweight='bold')
ax2.axvline(x=18500, c='red')
cbar = plt.colorbar(vals, orientation='horizontal')
cbar.set_label('Potencia ((m/s)^2/sqrt(Hz))', fontweight='bold')
```



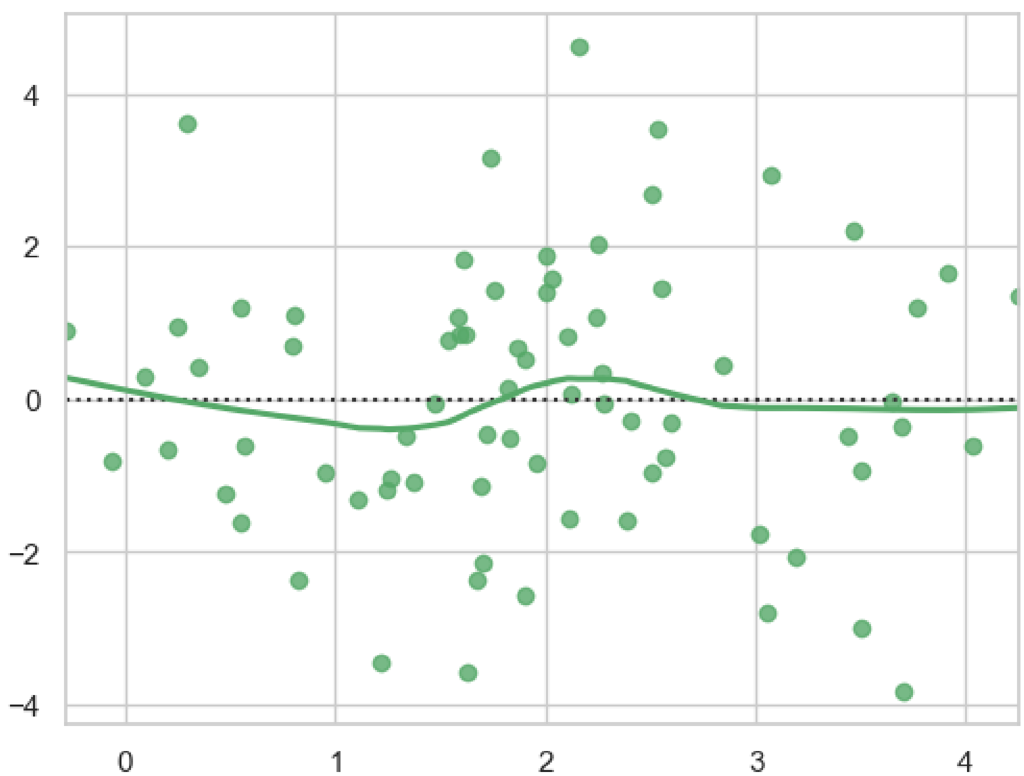
#

Analisis para entrenamiento

0.10 Graficacion de residuales de tiempo y velocidad a partir de la media

[71]:
```
import numpy as np
import seaborn as sns
sns.set_theme(style="whitegrid")

# Valores de frecuencia contra velocidad
rs = np.random.RandomState(7)
x = rs.normal(2, 1, 75)
y = 2 + 1.5 * x + rs.normal(0, 2, 75)

# Comparacion de modelo elemental y residuales
sns.residplot(x=x, y=y, lowess=True, color="g")
```

[71]:
```
<Axes: >
```

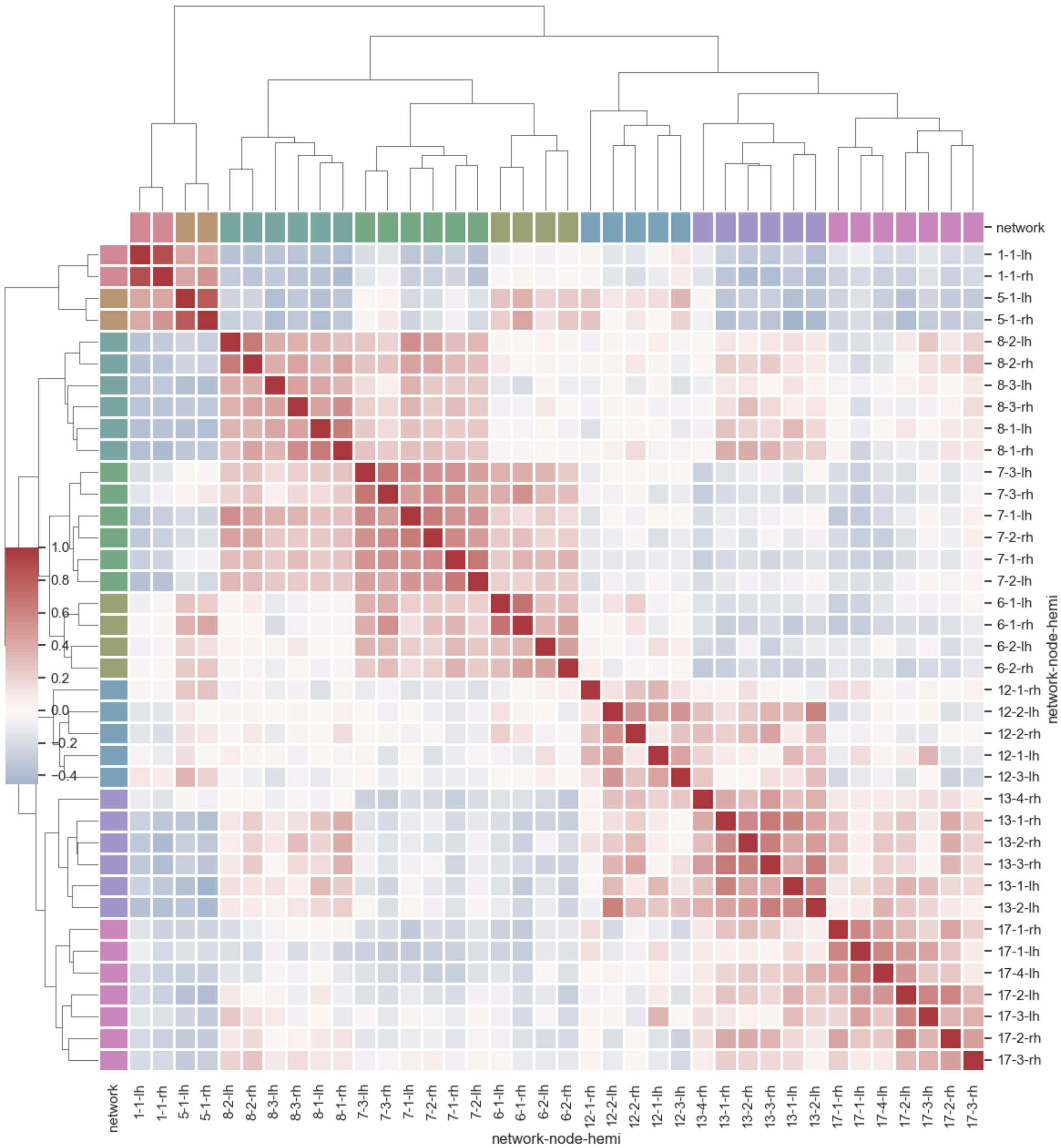


[72]:
```
import pandas as pd
import seaborn as sns
sns.set_theme()
```

0.11 Graficacion de datos de sismo mediante dispersion

[73]:

```
# carga del dataset
df=pd.read_csv("datos_sismo_procesados.csv", header=[0, 1, 2], index_col=0)

# Seleccion de variables del frame
used_networks = [1, 5, 6, 7, 8, 12, 13, 17]
used_columns = (df.columns.get_level_values("network")
                          .astype(int)
                          .isin(used_networks))
df = df.loc[:, used_columns]

# identificacion categorica
network_pal = sns.husl_palette(8, s=.45)
network_lut = dict(zip(map(str, used_networks), network_pal))

# Generacion de vector de valores
networks = df.columns.get_level_values("network")
network_colors = pd.Series(networks, index=df.columns).map(network_lut)

# graficacion de cluster de variables
g = sns.clustermap(df.corr(), center=0, cmap="vlag",
                   row_colors=network_colors, col_colors=network_colors,
                   dendrogram_ratio=(.1, .2),
                   cbar_pos=(.02, .32, .03, .2),
                   linewidths=.75, figsize=(12, 13))
```



0.12 Categorizacion de sismos

[74]:
```
sns.set_theme(style="whitegrid", palette="muted")

# carga del dataset
df2 =pd.read_csv("categorias_sismos.csv")

# Draw a categorical scatterplot to show each observation
ax = sns.swarmplot(data=df2, x="MAGNITUD", y="lugar", hue="tipo")
ax.set(ylabel="")
```

[74]: [Text(8.250000000000002, 0.5, '')]