Metadata_and_instrumentation

July 3, 2020

1 Obtaining metadata and experimenting with response removal

The goal of this exercise is to explore different options in ObsPy's remove_response method and how they affect the output signal after deconvolution. Explore lots of different options, change the settings to request data from a station and earthquake of interest to you, and remember you can always re-start the notebook!

You may want to start by taking a look at the documentation for remove_response: https://docs.obspy.org/packages/autogen/obspy.core.trace.Trace.remove_response.html

We'll start with the usual imports:

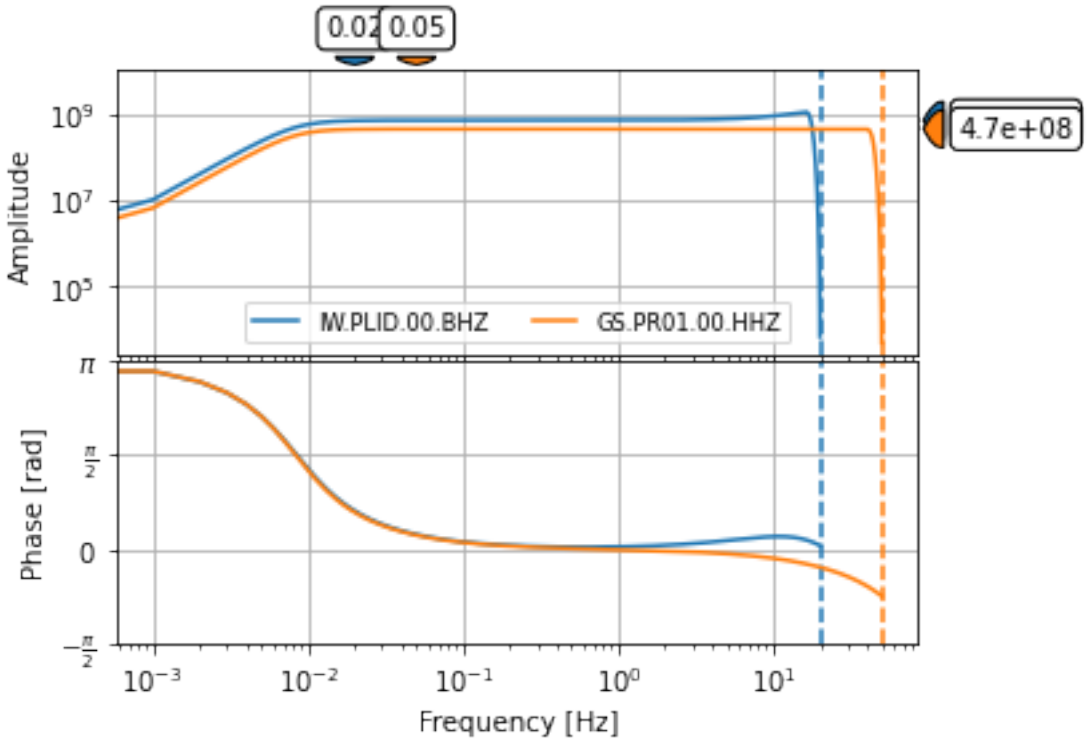
[1]:
```
import obspy
from obspy.clients.fdsn import Client

# Edit client to use your data center of interest
client = Client("IRIS")
```

List of available clients: https://docs.obspy.org/packages/obspy.clients.fdsn.html

[2]:
```
# Edit this to request metadata from your favorite station(s)
t1 = obspy.UTCDateTime("2020-07-01")
inv = client.get_stations(network="IW", station="PLID", channel="BHZ",␣
 ↪level="response", starttime=t1)
inv += client.get_stations(network="GS", station="PR01", channel="HHZ",␣
 ↪level="response", starttime=t1)
# may get a warning about StationXML1.1 -- OK to ignore it
```

```
/Users/utpalkumar50/miniconda3/envs/roses/lib/python3.7/site-
packages/obspy/io/stationxml/core.py:84: UserWarning: The StationXML file has
version 1.1, ObsPy can deal with version 1.0. Proceed with caution.
  root.attrib["schemaVersion"], SCHEMA_VERSION))
```

[3]:
```
inv.plot_response(min_freq=1e-3)
inv.write("inventory.xml", format="stationxml")
print(inv)
```




```
Inventory created at 2020-07-02T17:21:09.802508Z
        Created by: ObsPy 1.1.0
                    https://www.obspy.org
        Sending institution: IRIS-DMC (IRIS-DMC)
        Contains:
                Networks (2):
                        GS, IW
                Stations (2):
                        GS.PR01 (PR01, Lajas)
                        IW.PLID (Pearl Lake, Idaho, USA)
                Channels (2):
                        GS.PR01.00.HHZ, IW.PLID.00.BHZ
```

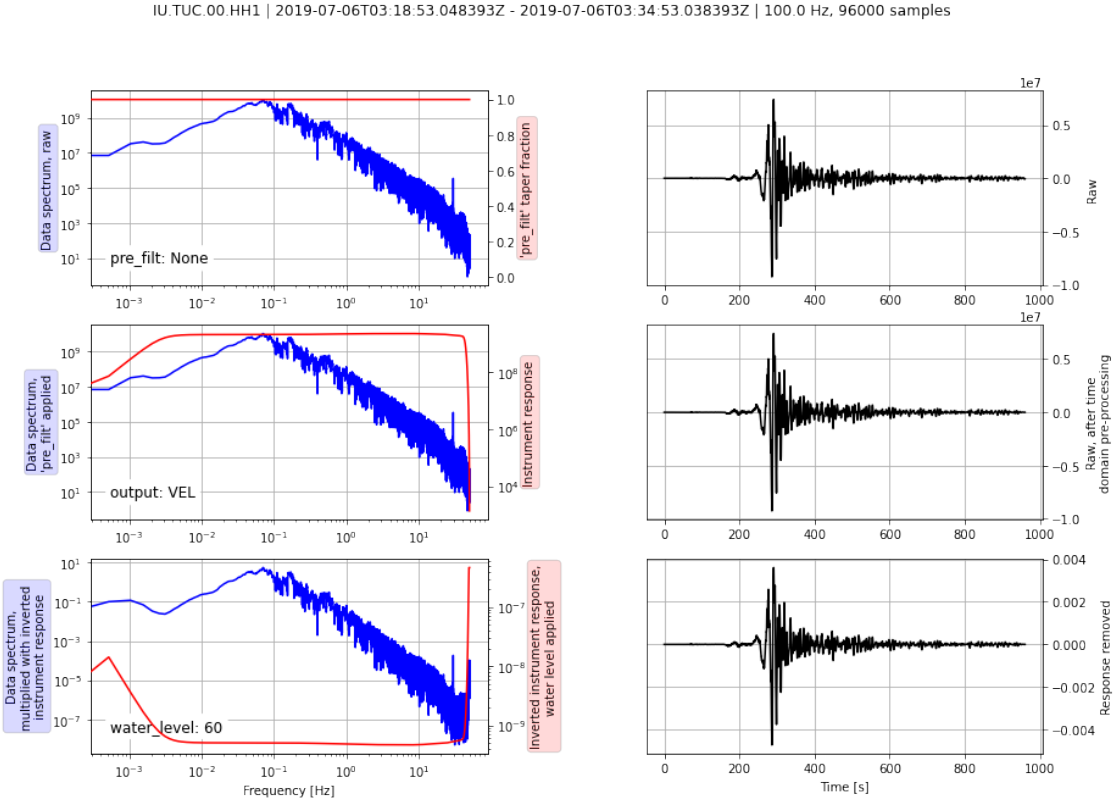
Let's revisit the example Sydney showed in Unit 1 using the 2019 M7.1 Ridgecrest earthquake and GSN station IU.TUC in Tucson, Arizona.

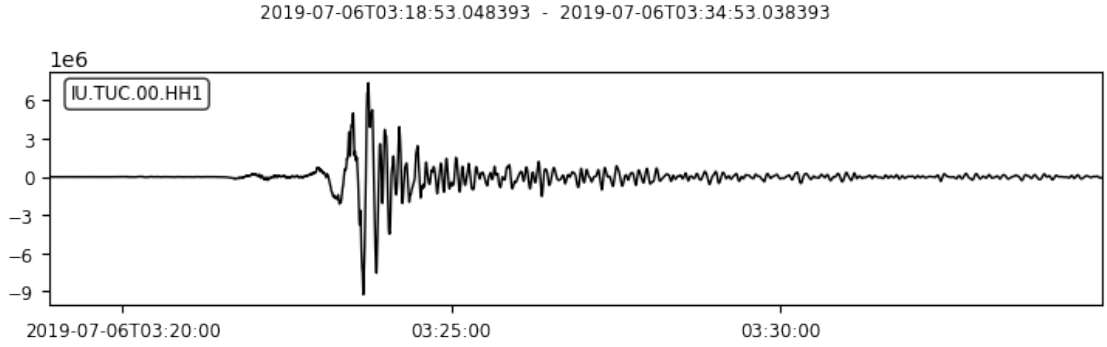
[4]:
```
time = obspy.UTCDateTime("2019-07-06T03:19:53.04")
starttime = time - 60
endtime = time + 60*15

net = "IU"
sta = "TUC"
loc = "00"
chan = "HH1"
```

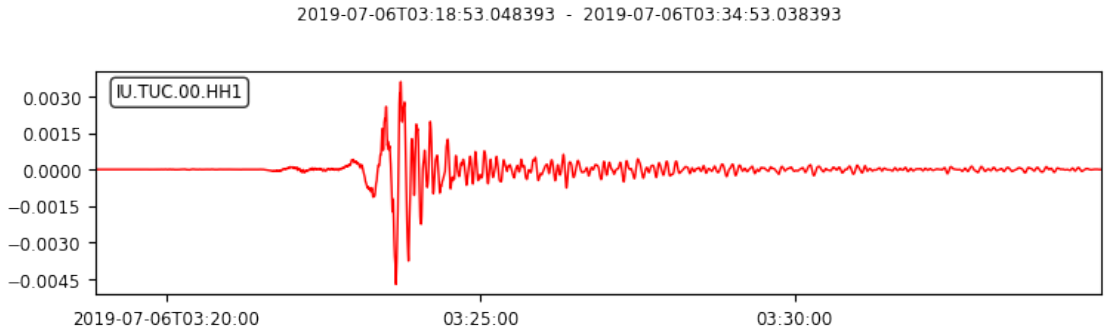
```
# Requesting waveforms with attach_response=True tells ObsPy to request an␣
 ↪inventory object for the channels requested
# st.
st = client.get_waveforms(net, sta, loc, chan, starttime, endtime,␣
 ↪attach_response = True)
print(st)

st_rem = st.copy() # make a copy of our original stream so we can try different␣
 ↪options later

st_rem.remove_response(output = 'VEL', plot = True) # Use ObsPy defaults to␣
 ↪remove response
# What happens if you choose a different water_level?  What if you set␣
 ↪water_level = 0?

st.plot()
st_rem.plot(color='red');

# Remember, if you remove the response from the same trace multiple times, your␣
 ↪output will be strange (and non-physical).
# This is why we make a new copy of st for each example below.
```

```
/Users/utpalkumar50/miniconda3/envs/roses/lib/python3.7/site-
packages/obspy/io/stationxml/core.py:84: UserWarning: The StationXML file has
version 1.1, ObsPy can deal with version 1.0. Proceed with caution.
  root.attrib["schemaVersion"], SCHEMA_VERSION))
```

```
1 Trace(s) in Stream:
IU.TUC.00.HH1 | 2019-07-06T03:18:53.048393Z - 2019-07-06T03:34:53.038393Z |
100.0 Hz, 96000 samples
```


IU.TUC.00.HH1 | 2019-07-06T03:18:53.048393Z - 2019-07-06T03:34:53.038393Z | 100.0 Hz, 96000 samples
Data spectrum, raw
pre_filt: None
'pre_filt' taper fraction
Data spectrum, 'pre_filt' applied
output: VEL
Instrument response
Data spectrum, multiplied with inverted instrument response
water_level: 60
Inverted instrument response, water level applied
Frequency [Hz]
Raw
Raw, after time domain pre-processing
Response removed
Time [s]


2019-07-06T03:18:53.048393 - 2019-07-06T03:34:53.038393
1e6
IU.TUC.00.HH1
2019-07-06T03:20:00
03:25:00
03:30:00

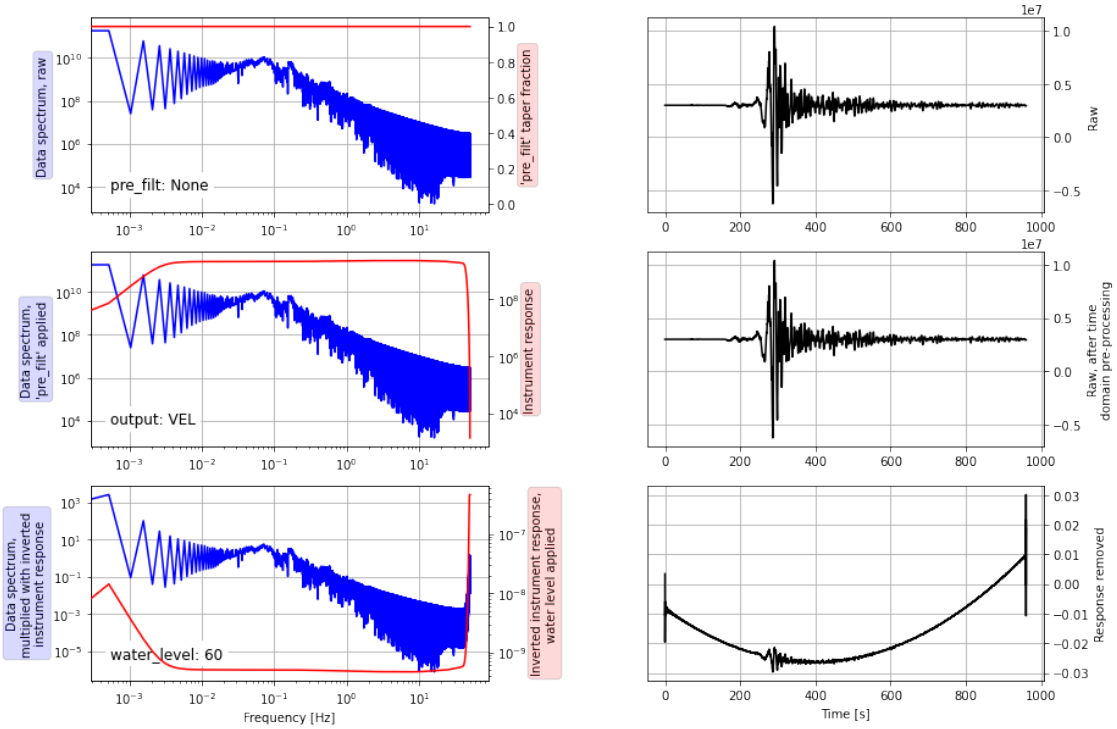


By default, ObsPy removes the mean of the signal and applies a 5% cosine taper to the ends of the signal before removing the response: https://docs.obspy.org/packages/autogen/obspy.core.trace.Trace.remove_response.html

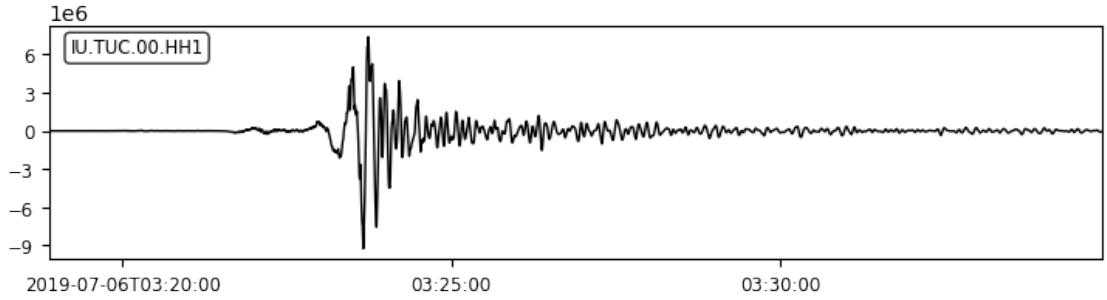
Let's explore what happens if we don't remove the mean or taper the signal. We'll also add a larger offset to the data to mimic a seismometer with masses that have drifted off-center (a common occurrence).

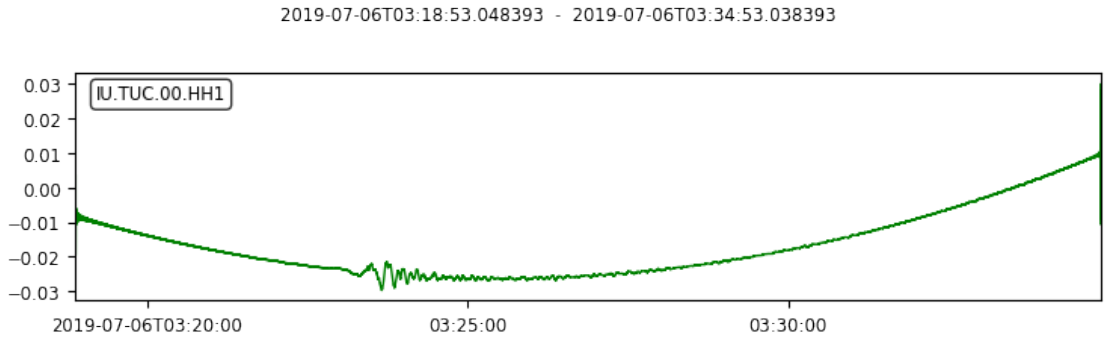
[5]:
```
st_rem = st.copy() # repeating this since the last cell will have removed the␣
 ↪response from st_rem already

# ObsPy's remove_response command automatically removes the mean and applies a␣
 ↪5% taper
# This supresses low and high-frequency artifacts
# What happens if you turn these off?
# Let's add a big offset to the data to exaggerate the effects
st_rem[0].data = st_rem[0].data + 3e6
st_rem.remove_response(output = 'VEL', plot = True, taper=0, zero_mean=False)

st.plot()
st_rem.plot(color='green');
```

IU.TUC.00.HH1 | 2019-07-06T03:18:53.048393Z - 2019-07-06T03:34:53.038393Z | 100.0 Hz, 96000 samples



2019-07-06T03:18:53.048393 - 2019-07-06T03:34:53.038393



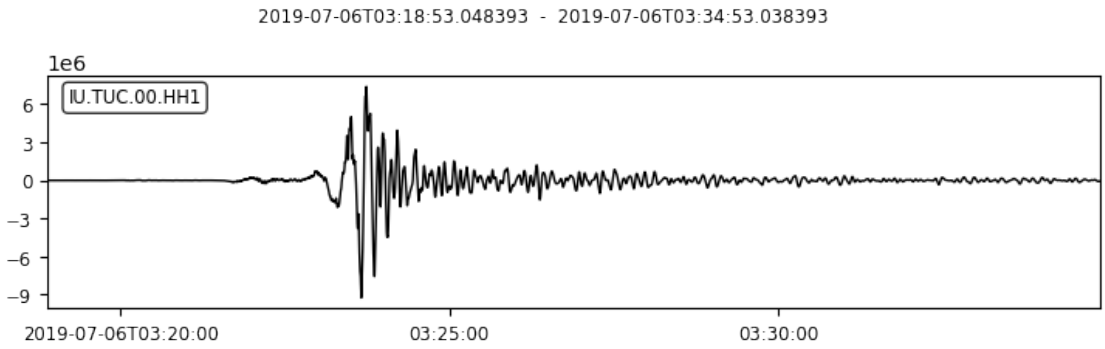


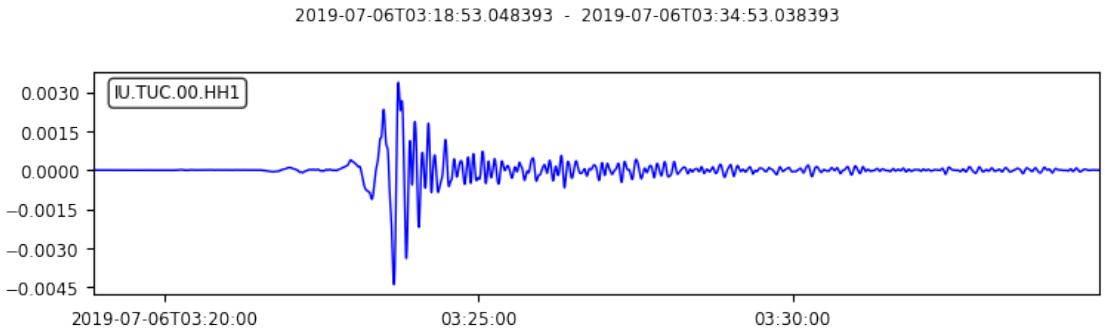
You can also use the pre_filt option to apply a filter to your data before removing the response. This helps stabilize the deconvolution and avoids blowing up long-period noise.

[6]:
```
st_rem = st.copy() # repeating this since the last cell will have removed the␣
 ↪response from st_rem already

# Use pre_filt command to filter the signal in your frequency band of interest
# Here's an example with pre_filt parameters useful for surface-wave studies
# Experiment with changing the 4 frequencies to see how this modifies the red␣
 ↪pre_filt curve in the first row of plots
# Try modifying it to a frequency band that emphasizes body waves (~1 s) and␣
 ↪filters out surface waves (~10s-100s of sec)
# Note: pre_filt is specified in Hz
# Remember: best not to work too close to Nyquist (highest freq should be no␣
 ↪higher than about 0.75*fny)
print(st_rem[0].stats.sampling_rate)
st_rem.remove_response(output = 'VEL', plot = True, pre_filt=[0.0036, 0.006, 0.
 ↪1, 0.5])

st.plot()
st_rem.plot(color='blue');
```

```
100.0
```

```
<Figure size 432x288 with 0 Axes>
```


2019-07-06T03:18:53.048393 - 2019-07-06T03:34:53.038393
1e6
IU.TUC.00.HH1
6
3
0
−3
−6
−9
2019-07-06T03:20:00
03:25:00
03:30:00


2019-07-06T03:18:53.048393 - 2019-07-06T03:34:53.038393
IU.TUC.00.HH1
0.0030
0.0015
0.0000
−0.0015
−0.0030
−0.0045
2019-07-06T03:20:00
03:25:00
03:30:00

[ ]: