Example usage of SeisSrcMoment to calculate M_W in the frequency domain

This example is for a volcano-tectonic earthquake at Uturuncu, Bolivia. The moment magnitude, M_W, is calculated in the frequency domain, i.e. the long period spectral level is calculated by fitting a Brune model, as detailed in Stork et al (2014). This earthquake's moment tensor is analysed in Alvizuri and Tape (2016), with M_W = 2.80 found by full waveform moment tensor inversion.

1. Specify parameters to use:

In [6]:

```
import numpy as np
from SeisSrcMoment import moment
from NonLinLocPy import read_nonlinloc
```

In [1]:

```
# Specify variables:
inventory_fname = "data/instrument_gain_data/IRISDMC-Plutons_dataless.dataless"
# The inventory fname, pointing to the dataless file for the network (for full i
nstrument frequency response removal)
mseed_filename = "data/mseed_data/20100516063454720000.m" # Note: One can pass t
he script an obspy stream instead if one wishes.
NLLoc_event_hyp_filename = "data/NLLoc_data/loc.Tom_RunNLLoc000.20100516.063457.
grid0.loc.hyp"
stations_not_to_process = []
window_before_after = [0.1, 0.6] # The time before and after the phase pick to u
se for calculating the magnitude within
filt_freqs = [0.5, 49.0] # Filter frequencies to apply (important if not removin
g long period spectral noise)
MT_six_tensor = [] # If this is not specified, assumes average DC component in P
(or S) from Stork et al (2014).
density = 2750. #2000. # Density of medium, in kg/m3
Vp = 5000. # P-wave velocity in m/s
# Note that Q not required as the program calculates Q when fitting the source m
odel.
use_full_spectral_method = True
verbosity_level = 0 # Verbosity level (1 for moment only) (2 for major parameter
s) (3 for plotting of traces)
plot_switch = True
remove_noise_spectrum = False # If True, removes noise using spectrum taken from
window before trace. Not thoroughly tested yet, but can get around by applying a
high pass filter above anyway.
```

In [8]:

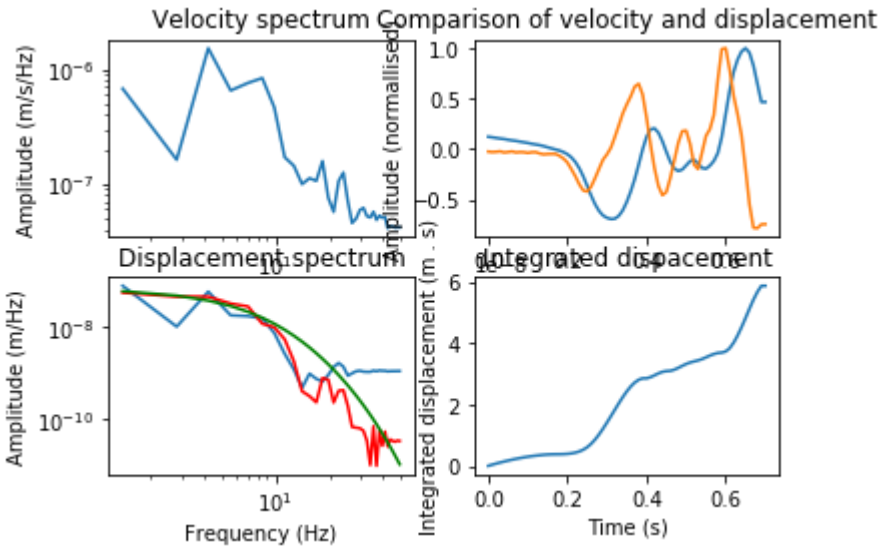
```
# Read in stations to calculate for directly from nonlinloc hyp file:
nonlinloc_event_hyp_data = read_nonlinloc.read_hyp_file(NLLoc_event_hyp_filename
)
stations_to_calculate_moment_for = list(nonlinloc_event_hyp_data.phase_data.keys
())
```

Run moment calculation:

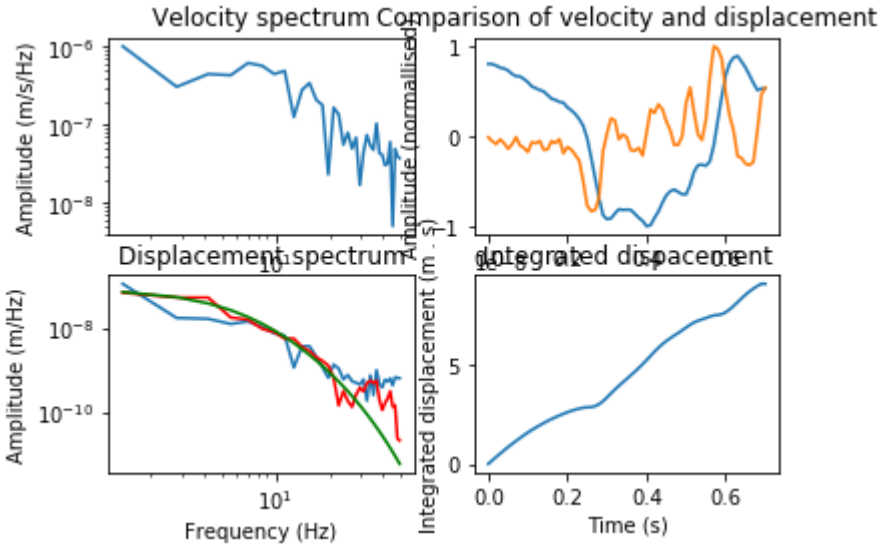
In [10]:

```
# Find seismic moment release:
av_M_0, std_err_av_M_0, n_obs, event_obs_dict = moment.calc_moment(mseed_filenam
e, NLLoc_event_hyp_filename, stations_to_calculate_moment_for, density, Vp, inve
ntory_fname=inventory_fname, window_before_after=window_before_after, filt_freqs
=filt_freqs, use_full_spectral_method=use_full_spectral_method, stations_not_to_
process=stations_not_to_process, MT_six_tensor=MT_six_tensor, verbosity_level=ve
rbosity_level, plot_switch=plot_switch)
print("Seismic moment release (Nm):", av_M_0)
```

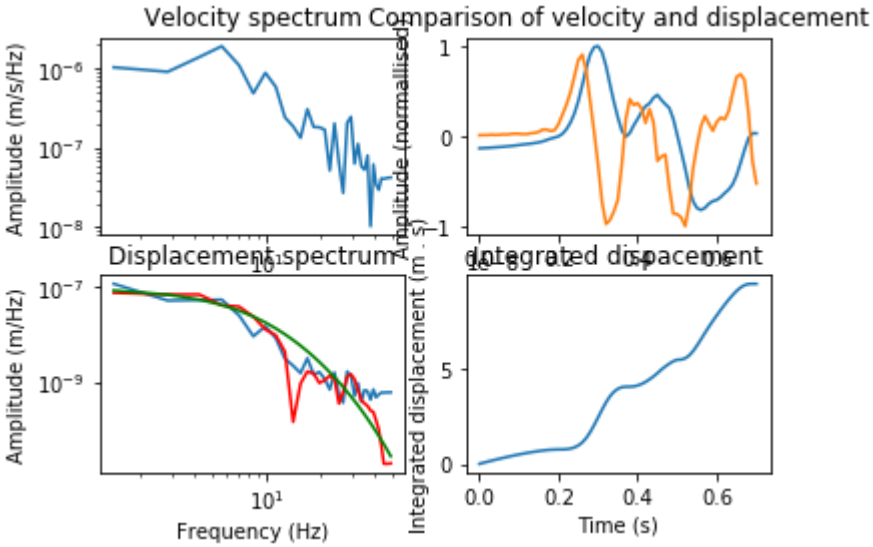
```
Warning: Need to specify MT_six_tensor or MT_data_filename for accur
ate radiation pattern correction.
 Using average radiation pattern value instead.

/Users/eart0504/opt/anaconda3/lib/python3.7/site-packages/obspy/io/x
seed/fields.py:377: UserWarning: Date is required.
  warnings.warn('Date is required.', UserWarning)
/Users/eart0504/opt/anaconda3/lib/python3.7/site-packages/obspy/sign
al/detrend.py:31: FutureWarning: Conversion of the second argument o
f issubdtype from `float` to `np.floating` is deprecated. In future,
it will be treated as `np.float64 == np.dtype(float).type`.
  if not np.issubdtype(data.dtype, float):

Station (PLLO) or channel (HHN) not in instrument inventory, therefo
re not correcting for this component and removing it.
Station (PLLO) or channel (HHE) not in instrument inventory, therefo
re not correcting for this component and removing it.
Station (PLLO) or channel (HHZ) not in instrument inventory, therefo
re not correcting for this component and removing it.
Sigma_0: 7.081226631247064e-08 f_c: 10.055787013239904 t_star: 0.035
57862597744755
```



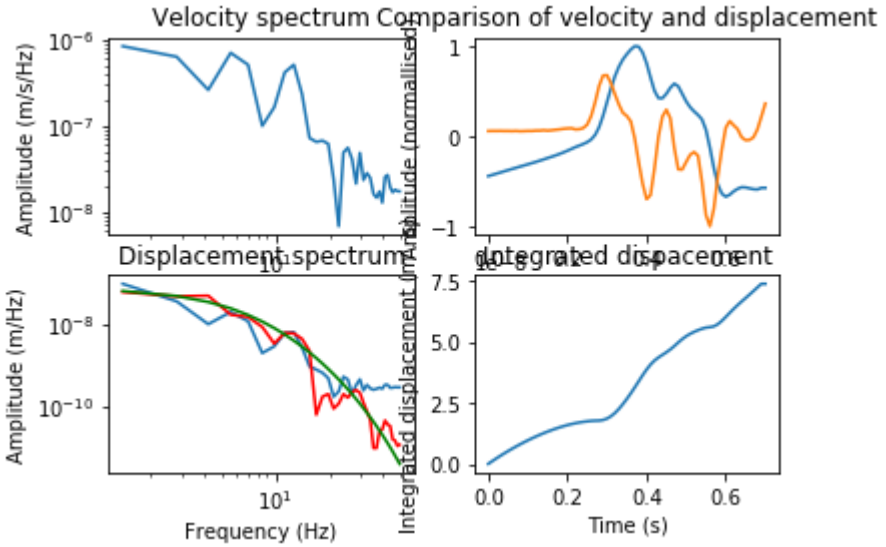

```
Sigma_0: 8.965846391157487e-08 f_c: 6.532205479084794 t_star: 0.0352
5616473498924
```



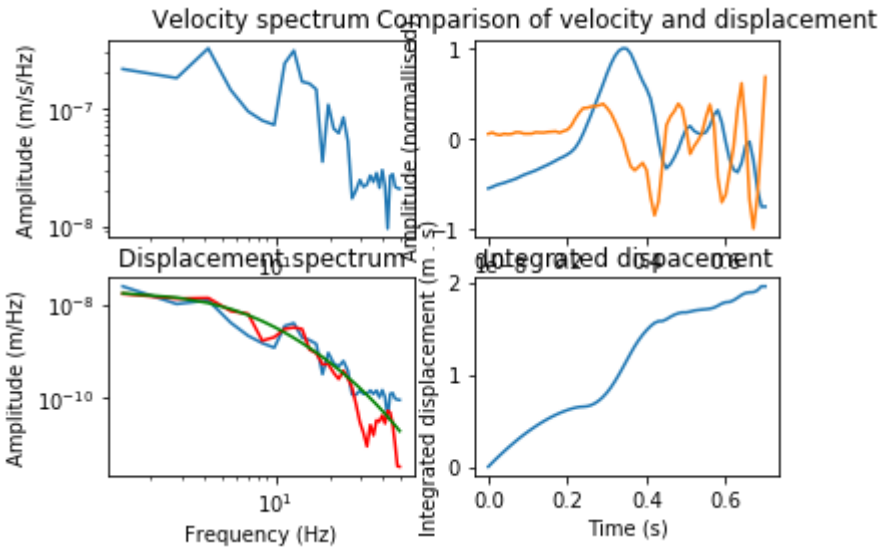

```
Sigma_0: 9.875372519344738e-08 f_c: 9.517629242631145 t_star: 0.0308
46363104357177
```



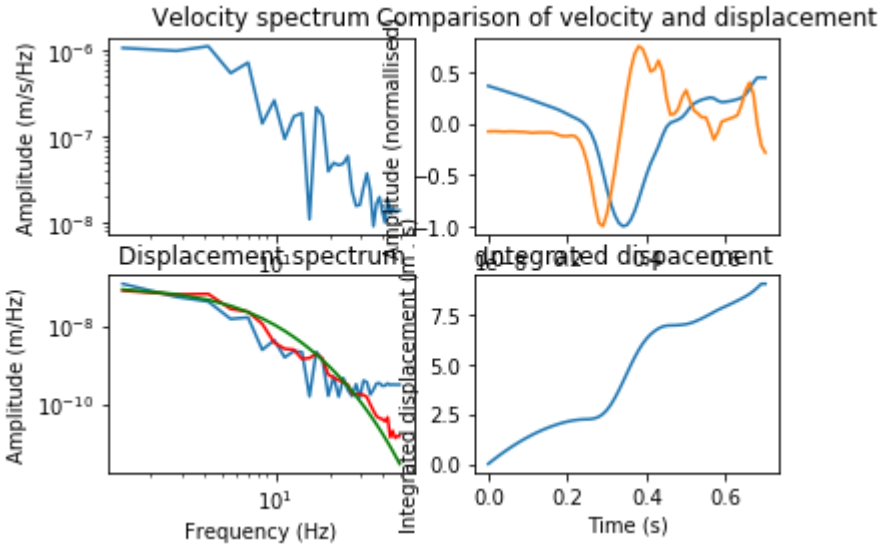

```
Sigma_0: 7.810585924953551e-08 f_c: 7.108672819864915 t_star: 0.0377
7633162509596
```




```
Sigma_0: 1.976462835659904e-08 f_c: 6.432798077441835 t_star: 0.0177
6713900937713
```




```
Sigma_0: 1.1012044324853064e-07 f_c: -7.998193523331016 t_star: 0.04
3440263611975824
```




```
Seismic moment release (Nm): 16061623033951.943
```

In [11]:

```
# And find corresponding moment magnitude, M_w (Hanks and Kanamori 1979):
M_w = (2./3.)*np.log10(av_M_0) - 6.0
print("Local moment magnitude, M:", M_w)
```

```
Local moment magnitude, M: 2.803859619203539
```

Note that this magnitude is approximately the same as that found in Alvizuri and Tape (2016), where they found that $M_W = 2.80$.

References:

Alvizuri, C., & Tape, C. (2016). Full moment tensors for small events (Mw < 3) at Uturuncu volcano, Bolivia. Geophysical Journal International, 206(3), 1761–1783. https://doi.org/10.1093/gji/ggw247 (https://doi.org/10.1093/gji/ggw247)

Stork, A. L., Verdon, J. P., & Kendall, J. M. (2014). The robustness of seismic moment and magnitudes estimated using spectral analysis. Geophysical Prospecting, 62(4), 862–878. https://doi.org/10.1111/1365-2478.12134 (https://doi.org/10.1111/1365-2478.12134)

In [ ]: