

SIO 227B – Practical 1

On the Macs in the barnyard, log into class227 (password is sio227b). Open a terminal window (tsh is better than bash so run `/bin/tsh` if you default as a bash shell) – also you should start X11. You may have to type `'source .cshrc'` to get access to programs (which are in `class227/bin`). In the directory "data.dir", you will find some files of seismic recordings of a few of the large recent earthquakes. These files are "GFS" files which are really Unix directories and can be manipulated with appropriate software. For example, typing `"curse bolivia94bp.gfs"` will start the interactive editor on the vertical component recordings of the Bolivian earthquake. BEWARE! It is easy to change data with this program.

Of the several events in the directory, 2 are deep (Flores and Bolivia) and the rest are shallow. Choose 1 deep and 1 shallow event and use RSPEC to look at amplitude spectra of various recordings. This program allows you to change record length and start time, taper type, frequency sampling, etc, and to zoom in frequency and use the cursor to measure peak frequencies. (The reprint from the AGU volume by Masters and Widmer has a listing of mode frequencies with an indication of which modes have (and can) be observed.)

1. Part 1

At first, all I really want you to do is to play and get a feel for how the spectrum changes depending on how you compute it. For example, using the Bolivian data, you can use 50 hours of recording starting 0, 10, and 20 hours after the event and look at spectra in the 1–3 mHz band and the 2–6 mHz band. Play with tapers (though the Hanning will probably be best). Now use a very long record (e.g. 100 hours). Now do the same thing for one of the shallow events. Some narrow frequency bands have two closely spaced modes with very different Q values (e.g. ${}_3S_{1/1}S_3$ or ${}_8S_{1/0}S_{20}$) and you should experiment to see if you can separate the modes using the Earth as an "attenuation filter". On records of the deep events, you'll be able to see splitting of some high Q modes if you take a long enough record. How long a record do you have to take to see splitting of ${}_{13}S_2$?

2. Part 2

Use program TPDSK to estimate the frequencies and Q 's of the following modes: ${}_0S_{20}$, ${}_0S_{25}$, ${}_0S_{30}$, and ${}_0S_{35}$. You should use about Q cycles of data for each mode and start about 1 hour into the recordings. The program will prompt you with the calculated value for Q cycles though you should not use less than about 8 hours since record truncation effects then broaden the spectrum too much. You can also adjust the frequency spacing chosen by the program. There should be 6 to 10 points above the half-amplitude point of the mode and the bigger you make the frequency spacing the more of the spectrum you will see (the program plots 50 points). Seeing more of the spectrum makes it easier to evaluate noise levels. Figure 1 shows the result of using TPDSK on a BFO record to measure ${}_0S_{25}$. The measured frequency is about 3.3588mHz and $1000/Q$ is 3.28. You use the cross-hair to estimate signal to noise which then allows the program to calculate errors. This estimate had a SNR of about 22 giving an error in frequency of $0.5\mu\text{Hz}$ and an error in $1000/Q$ of 0.29. The results are written to an ASCII file (an example is shown in figure 2). Discard measurements with low SNR (a peak amplitude to noise ratio of about 3 is the minimum signal level you should consider) and discard measurements which do not de-mode properly. Pool your results so that you have as many measurements as possible for each mode. Explore your data (e.g. make histograms and look for outliers). Plot up the statistics of your measurements (mean, median, variance, s.d. of mean, SMAD, etc.) and try and interpret your results. (Note that it makes more sense to plot the difference between your frequency estimates and the spherical Earth estimates in the review paper as a function of harmonic degree – though it is fine to plot the absolute attenuation estimates as a function of harmonic degree since their errors are relatively large). In particular, try to explain why the mean attenuation varies as it does as a function of harmonic degree; explain what you think causes the scatter in attenuation and frequency measurements; explain why you think the variance of the measurements changes as a function of harmonic degree; explain your reasons for discarding measurements. Since you have error estimates on both your frequency and

Q measurements, decide if the observed scatter in the data is consistent with the estimated errors (use a statistical test).

(Note that it makes more sense to plot the difference between your frequency estimates and the spherical Earth estimates in the review paper as a function of harmonic degree – though it is fine to plot the absolute attenuation estimates as a function of harmonic degree since their errors are relatively large. Use $1000/Q$ as your measure of attenuation. $1000/Q$ is typically between 0 and 10 whereas Q lies between 100 and infinity.)

Now use program TPDSK to estimate the frequency and Q of the radial mode ${}_1S_0$ using records from the 2010 Chilean event and 2004 Sumatran event. You should use about 200 hours of data. From your measurements, compute the (weighted) mean and standard deviation – do your answers make sense from the point of view of the individual estimated errors (use a statistical test!). Why are your results qualitatively different from your results for the fundamental modes?

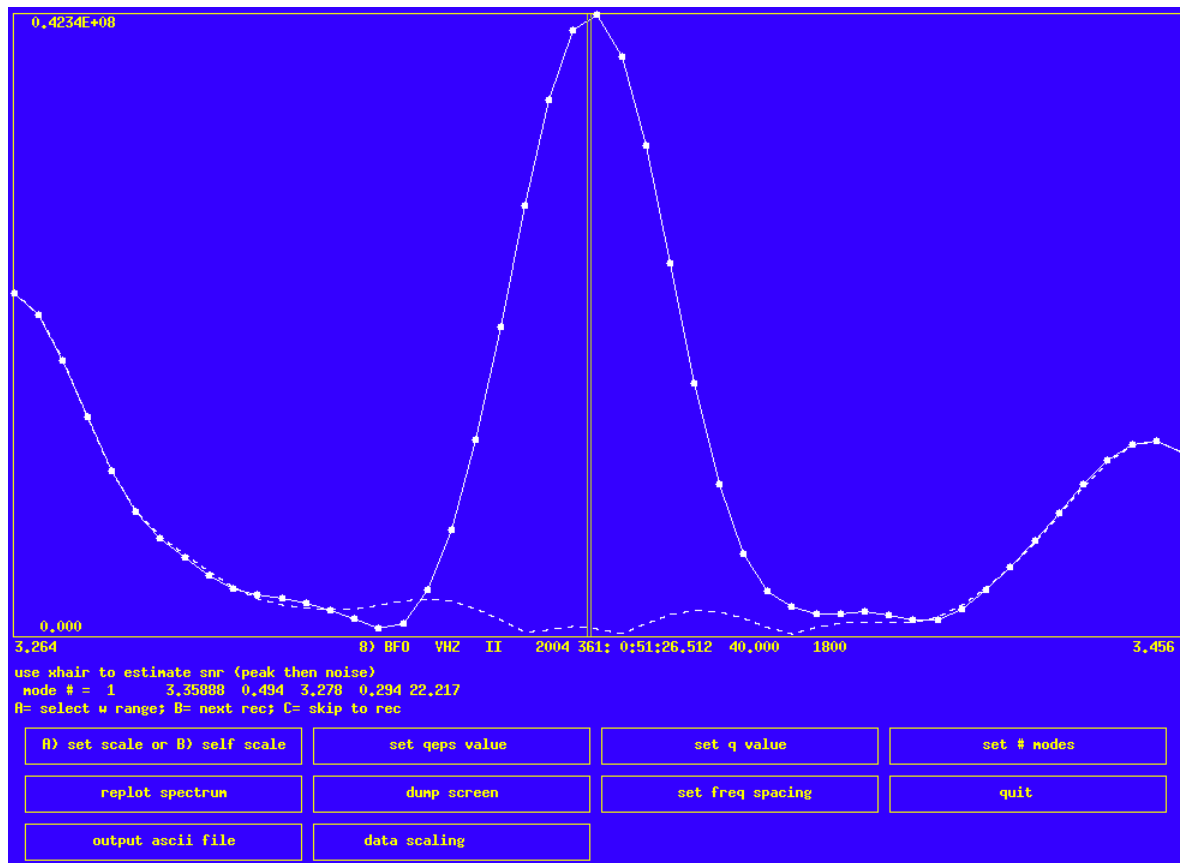


Figure 1. A sample of the screen after demoding

	mode	freq(mHz)	1000/Q	stat	yr	dy	reclen(hr)	snr	%err in freq	%err in 1000/Q
9	0 S 25	3.3587601	4.7958451	AAK	2004	361	20.00	12.5	0.264E-01	0.110E+02
10	0 S 25	3.3587141	4.1953350	ANMO	2004	361	20.00	12.8	0.254E-01	0.121E+02
12	0 S 25	3.3580587	4.4628124	APE	2004	361	20.00	12.3	0.267E-01	0.120E+02
13	0 S 25	3.3581872	3.3868867	AQU	2004	361	18.14	8.7	0.416E-01	0.246E+02
14	0 S 25	3.3602467	4.4904616	ARU	2004	361	20.00	6.1	0.537E-01	0.239E+02
15	0 S 25	3.3588762	5.7982788	BBSR	2004	361	20.00	5.2	0.645E-01	0.222E+02
16	0 S 25	3.3589799	3.3378605	BFO	2004	361	20.00	17.7	0.185E-01	0.111E+02
18	0 S 25	3.3586967	3.5774443	BNI	2004	361	18.27	16.1	0.223E-01	0.125E+02
19	0 S 25	3.3566134	4.9419484	BRVK	2004	361	20.00	6.5	0.511E-01	0.207E+02
20	0 S 25	3.3504305	5.1579487	CASY	2004	361	20.00	5.5	0.608E-01	0.236E+02
21	0 S 25	3.3575056	3.6672283	CCM	2004	361	20.00	8.6	0.379E-01	0.207E+02
22	0 S 25	3.3571348	3.9378652	CEL	2004	361	18.20	20.5	0.175E-01	0.888E+01
23	0 S 25	3.3582523	3.4422518	CII	2004	361	20.00	12.3	0.266E-01	0.155E+02
24	0 S 25	3.3583345	4.6282330	COLA	2004	361	20.00	8.9	0.370E-01	0.160E+02
25	0 S 25	3.3593631	5.0904474	COR	2004	361	20.00	8.1	0.407E-01	0.160E+02
26	0 S 25	3.3568873	4.2839247	CSS	2004	361	20.00	8.3	0.395E-01	0.185E+02
27	0 S 25	3.3594253	3.0844301	CTAO	2004	361	20.00	9.4	0.348E-01	0.225E+02
29	0 S 25	3.3572524	4.1142760	DWPF	2004	361	20.00	6.8	0.480E-01	0.233E+02
31	0 S 25	3.3591869	3.6078951	ENH	2004	361	20.00	11.6	0.280E-01	0.155E+02
32	0 S 25	3.3589883	3.3019925	ESK	2004	361	20.00	16.0	0.205E-01	0.124E+02
33	0 S 25	3.3573349	4.6757323	FFC	2004	361	20.00	12.2	0.270E-01	0.115E+02
34	0 S 25	3.3577025	3.6686652	GNI	2004	361	20.00	11.4	0.287E-01	0.156E+02
35	0 S 25	3.3592393	4.5298418	HIA	2004	361	20.00	13.5	0.243E-01	0.107E+02

Figure 2. A sample of the output of tpdsk