NAME

psd − Background Noise Power Spectral Density Estimation

SYNOPSIS

psd *seed_data_volume*

DESCRIPTION

psd is a background noise acceleration Power Spectral Density (PSD) estimation algorithm designed specifically to extract all necessary information and data for calculating the PSD estimates from a SEED data volume. It is an exportable version of the acceleration PSD algorithm that has been in routine use at the Berkeley Seismological Laboratory (BSL) for approximately the past decade. The **psd** algorithm is a script that calls a series of three algorithms that extract the requisite station coordinate, sensor transfer function, and data files. The essential components of the **psd** script are:

```
rdseed -s -f $sdv > sdv_temp
```

which uses "rdseed" to retrieve all station and channel header information from the SEED data volume "$sdv" and write it to a temporary file "sdv_temp";

```
grep B050F sdv_temp | sdv_coord > instr.sdv.coord
```

which does a pattern grep on the station coordinate entries in the sdv_temp file and uses the supplied "sdv_coord" algorithm to generate "instr.sdv.coord" containing the station coordinate information;

```
grep B05 sdv_temp | sdv_resp > instr.sdv.resp
```

which does a pattern grep on the station sensor entries in the sdv_temp file and uses the supplied "sdv_resp" algorithm to generate "instr.sdv.resp" containing the sensor transfer functions and related information;

```
rdseed -d -o 1 -f $sdv
```

which uses "rdseed" to dump the data records in SAC binary format; and finally a foreach loop:

```
foreach sbdf (‘ls | grep SAC‘)
  sdv_psdest $sbdf
  set x = $status
  if ( $x == 0 ) then
    \rm $sbdf
    echo File $sbdf processed.
  else
    set np = ‘sdv_sacnpts $sbdf | grep npts | awk ’{ print $3 }’‘
    echo File $sbdf contained only $np samples.
  endif
end
```

to process each of the SAC binary data files, that contain at least 65536 data samples without any time gaps, and calculate the acceleration PSD estimate using the "sdv_psdest" algorithm.

The *sdv_psdest* algorithm was intentionally designed to operated in an automated fashion without any optional command line arguments. This minimizes the possibility of inappropriate use of the algorithm that could produce biased PSD estimates. The original in-house version of the *sdv_psdest* algorithm used at the Berkeley Seismological Laboratory was written in Fortran 77. The *f2c* translator was used to convert the Fortran 77 source code to C source files. The Fortran 77 source code was cleaned up and necessary subrouutines, not included in the *f2c* libraries, were added to expedite the conversion process.

The *sdv_coord* and *sdv_resp* algorithms were converted in a similar fashion. The only *f2c* option used in the conversion was "-c" which causes the original Fortran 77 source code to be embedded as comments in the C source files.

The *sdv_psdest* algorithm uses a statistical approach to robustly estimate the background noise PSD. The input time series is parsed into eight (possibly overlapping) time series and each of the resulting time series are appropriately windowed prior to calculating their PSD estimates. For short time series, less than 1.5 hours in length, the time series are detrended and sine tapered while for longer time series the dominant semi-diurnal gravitational tide signal is also removed to avoid biasing the long-period PSD estimates. A caveat: since the transfer function representation in the SEED data volumes for typical broadband seismometers does not include the static component of the response, the background noise PSD estimates for periods longer than an approximately an hour will be biased high and hence they will be unreliable.

OPTIONS

The only command line option (required) for **psd** is the name of the SEED data volume which is to be processed:

seed_data_file

The SEED data volume provides the algorithms in **psd** with all the requisite information for calculating the background noise PSD esrimates.

OUTPUT

Besides the information that is printed to the screen, **psd** outputs a station coordinate file *instr.sdv.coord*, a sensor transfer function file *instr.sdv.resp*, and a file with a ".psd" suffix for each data stream, that meets the minimum requirements of the PSD estimation algorithm, extracted from the SEED data volume.

EXAMPLE FILE - *instr.sdv.coord*

Invoking

psd *ybh_sdv*, as shown in the example subdirectory, will extract the requisite data from the *ybh_sdv* SEED data volume and genrate an *instr.sdv.coord* file containing:

```
YBH  BK  41.7320400  -122.7103880  1059.70  1996.296.0000  3000.001.0000  Yreka Blue Horn
```

where the columns are: station, network, latitude, longitude, elevation, start date, end date, and location.

EXAMPLE FILE - *instr.sdv.resp*

Invoking

psd *ybh_sdv* will also extract the requisite data from the ybh_sdv SEED data volume and genrate an *instr.sdv.resp* file containing the pole/zero/scaling constant representation of the transfer function for each sensor for which there is data in the SEED data volume:

```
YBH    BK    XX    LHE    1996.296.0000    3000.001.0000
    41.7320400     -122.7103880    1059.70      60.40
     90.00        .00    M/S
       .986864E+12     2     4
       .000000E+00     .000000E+00     .000000E+00     .000000E+00
      -.123412E-01     .123415E-01    -.123412E-01    -.123415E-01
```

```
    -.195878E+02    .245617E+02   -.195878E+02   -.245617E+02
YBH    BK   XX   LHN   1996.296.0000   3000.001.0000
   41.7320400    -122.7103880   1059.70     60.40
     .00       .00   M/S
     .911518E+12    2    4
     .000000E+00    .000000E+00    .000000E+00    .000000E+00
    -.123412E-01    .123415E-01   -.123412E-01   -.123415E-01
    -.195878E+02    .245617E+02   -.195878E+02   -.245617E+02
YBH    BK   XX   LHZ   1996.296.0000   3000.001.0000
   41.7320400    -122.7103880   1059.70     60.40
     .00    -90.00   M/S
     .962459E+12    2    4
     .000000E+00    .000000E+00    .000000E+00    .000000E+00
    -.123412E-01    .123415E-01   -.123412E-01   -.123415E-01
    -.195878E+02    .245617E+02   -.195878E+02   -.245617E+02
```

where, for each component: the first line gives the station code, network, location, data stream, start date, and end date; the second line gives the sensor latitude, longitude, elevation, and depth of burial; the third line gives the component azimuth, dip angle, and flat passband units; the fourth line gives the scaling constant, the number of complex zeros, and the number of complex poles; and the fifth through nth lines gives the complex zero values (no more than two complex numbers per line) followed by the complex pole values (also no more than two complex numbers per line). The sequence is repeated for each unique station code-network-location-component in the SEED data volume.

EXAMPLE PSD OUTPUT FILE - *YBH.BK.LHZ.XX.D.2000.178.0000.psd*

Invoking

psd *ybh_sdv* will also generate a PSD results file for each unique station code-network-location-component in the SEED data volume. The file naming follows the SEED convention and inserts an "XX" in the place of the location if the location is not specified. A ".psd" is appended to the SEED file name. An example of a PSD results file, YBH.BK.LHZ.XX.D.2000.178.0000.psd in the example subdirectory, is:

```
Acceleration Power Spectral Density Estimate
Processing Date     Wed Jul 19 14:35:57 PDT 2000
Network             BK
Station             YBH
Channel             LHZ
Location            XX
Number of points        86400
Sample rate (sps)       1.0000
Start Date/Time      2000  178    0    0    0  823
Length of FFT            16384
PSDs averaged                8
Points shifted          9919
Min & Max PSD No.          7         1
Min & Max std err        111.102661     148.638733 (in counts)
PSD in dB referenced to 1 (m/s**2)**2/Hz
     Period       PSD LB       PSD min      PSD med      PSD max      PSD UB
      (sec)        (db)         (db)         (db)         (db)         (db)
   1638.400     -168.38834   -167.02596   -165.35931   -166.20975   -161.43890
   1462.203     -169.37077   -168.00839   -166.34177   -167.19218   -162.42134
   1304.956     -170.34985   -168.98747   -167.32083   -168.17126   -163.40042
```

1164.619	-170.59071	-170.59071	-168.98082	-169.12317	-165.02768
1039.374	-171.47586	-171.47586	-169.56149	-170.68668	-167.32243
927.5980	-174.03415	-172.54893	-170.42093	-174.03415	-169.76917
827.8426	-172.76053	-170.93161	-171.51901	-172.76053	-170.92393
738.8151	-173.71457	-172.94249	-172.85071	-173.54900	-170.95023
659.3618	-174.41260	-173.87346	-173.72192	-172.83858	-172.83858
588.4529	-176.10869	-175.66737	-174.81923	-174.46793	-174.29036
525.1698	-177.34253	-177.34253	-176.36523	-174.62498	-174.62498
468.6922	-178.88013	-178.49683	-177.37491	-175.48476	-175.48476
418.2883	-179.96187	-179.34848	-178.80994	-176.54405	-176.54405
373.3049	-181.44315	-180.12718	-179.49158	-177.71735	-177.71735
333.1591	-182.72328	-180.18291	-180.31950	-178.60551	-178.60551
297.3306	-182.91478	-181.82552	-181.35762	-179.35602	-179.24556
265.3552	-183.00632	-181.94067	-181.94708	-180.65727	-180.28470
236.8185	-184.01825	-182.41615	-182.43581	-180.96719	-180.96719
211.3507	-183.98384	-182.60445	-182.67880	-181.35233	-180.98056
188.6217	-184.23106	-183.72298	-182.76050	-181.58556	-181.33028
168.3370	-184.32166	-183.54443	-182.89197	-181.84503	-181.84503
150.2338	-184.49385	-183.92537	-183.20618	-181.09390	-181.09390
134.0774	-184.44151	-184.44151	-183.52002	-180.95381	-180.95381
119.6585	-185.02162	-185.02162	-183.88831	-180.98755	-180.98755
106.7902	-185.31282	-185.31282	-184.10703	-179.60600	-179.60600
95.30582	-185.52632	-185.52632	-185.07741	-177.81160	-177.81160
85.05650	-186.34065	-186.34065	-185.56161	-176.58374	-176.58374
75.90942	-186.91449	-186.84898	-186.29384	-174.79771	-174.79771
67.74601	-187.70616	-187.49275	-186.73956	-172.36865	-172.36865
60.46051	-187.83774	-187.72551	-186.31906	-170.68539	-170.68539
53.95851	-187.91620	-187.76353	-185.26706	-169.37483	-169.37483
48.15574	-187.05426	-187.05426	-184.01324	-166.92999	-166.92999
42.97701	-186.24025	-186.24025	-182.00900	-163.91563	-163.91563
38.35520	-184.82481	-184.82481	-179.42068	-160.63492	-160.63492
34.23043	-182.48813	-182.48813	-176.48869	-157.28188	-157.28188
30.54925	-179.42862	-179.32231	-172.40747	-153.90202	-153.90202
27.26394	-176.59674	-176.50986	-168.71765	-151.26773	-151.26773
24.33194	-172.78209	-172.78209	-165.13660	-148.78032	-148.78032
21.71525	-168.58115	-168.41124	-162.72318	-148.36920	-148.36920
19.37996	-165.17551	-165.10526	-161.18213	-148.45227	-148.45227
17.29581	-162.85893	-162.85893	-160.04968	-147.59035	-147.59035
15.43580	-160.78381	-160.78381	-159.23019	-146.28749	-146.28749
13.77581	-160.08301	-159.56273	-159.13156	-145.16370	-145.16370
12.29434	-158.74533	-158.01352	-157.71356	-143.68265	-143.68265
10.97219	-156.61784	-155.44029	-155.16611	-141.71407	-141.71407
9.792231	-153.63385	-152.39557	-152.20276	-140.31293	-140.31293
8.739160	-149.49716	-148.58427	-148.33472	-139.13786	-139.13786
7.799337	-144.63336	-144.53076	-144.49423	-137.72183	-137.72183
6.960586	-141.74251	-141.65910	-141.22354	-135.97588	-135.97588
6.212034	-139.81697	-139.75848	-139.10432	-134.19365	-134.19365
5.543983	-137.49036	-137.49036	-137.00966	-132.71323	-132.71323
4.947774	-134.69475	-134.69475	-134.33992	-131.34843	-131.34843
4.415684	-132.76901	-132.68925	-132.51857	-130.15715	-130.15715
3.940814	-131.96111	-131.67375	-131.53299	-129.64851	-129.64851
3.517014	-130.97412	-130.68677	-130.54599	-128.66153	-128.66153
3.138789	-129.98746	-129.70010	-129.55933	-127.67486	-127.67486

where: the first 17 lines contain header information and the 18th through last lines give the acceleraion PSD estimates where the first column gives the period of PSD estimate in seconds and the remaining columns give the lower bound (LB), minimum (min), median (med), maximum (max), and upper bound (UB) of the background noise acceleration PSD estimate. The minimum (min) and maximum (max) columns refer to the estimates which have the minimum and maximum sums over all periods (the time series corresponding to each is given in the 13th header line) while the lower bound (LB) and upper bound (UB) columns give the lowest and highest estimate for each period. The PSD estimate in the "PSD min" column is the most robust estimate of the background noise PSD.

AUTHOR

Bob Uhrhammer, UC Berkeley Seismological Laboratory, Email: bob@seismo.berkeley.edu

BUGS

Report any bugs, problems or suggestions to the author.