

sacpsd

1. Introduction

The determination of power spectral density (PSD) of Earth noise is a useful tool for monitoring noise sources and also the performance of seismic instruments (McNamara and Buland, 2004). The purpose for writing this program is to be able to use routine PSD measurements as a tool for verifying the metadata for digital instrumentation and for checking on instrument performance.

Section 2 discusses the determination of a power spectral density from windowed data. After a quick introduction to the command line options of **sacpsd**, Section 3 focuses on real data from three sources. Section 4 describes how to obtain the acceleration sensitivity from pole-zero and RESP files. An Appendix follows that highlights the CALPLOT graphics package of Computer Programs in Seismology.

Although **sacpsd** source code is distributed with Computer Programs in Seismology, the following archive can be downloaded to obtain the shell scripts used to make the figures show in this documents. This file is [sacpsd.tgz](#).

While it is simple to use **sacpsd**, effort is required to get the time series and responses. Section 3 discusses how to obtain the data from USGS Continuous Wave Buffer (CWB) and FDSN data centers.

Since data access methods evolve, one should check for updates.

These access tools distributed here and their current links as of 03/13/26 are as follow:

Codes and links	
mseed2sac-2.4.tar.gz	https://github.com/EarthScope/mseed2sac
FetchData	https://earthscope.github.io/fetch-scripts/
Evalresp (distributed with CPS has xml2resp)	https://github.com/EarthScope/evalresp
CWBQuery (click on CWBQuery)	https://code.usgs.gov/groups/ghsc/neic/-/packages
jmdget.jar (click on GUI)	https://code.usgs.gov/groups/ghsc/neic/-/packages

The program **sacpsd** requires the instrument acceleration sensitivity (counts/m/s/s). This can be obtained from the displacement sensitivity pole-zero file or from the RESP file using **evalresp**.

2. Power Spectra

The computation of power spectra follows Ifeachor and Jervis (1993). Given a time series $x(k)$, we first correct that series to have a zero mean, apply a window, $w(k)$, and correct amplitudes for the

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windowing function. Their equation (10.16) defines the corrected time series, $s(k)$, as

$$s(k) = c_2 w(k) [x(k) - c_1]$$

where the constants are defined as

$$c_1 = \sum w(k)x(k) / \sum w(k) \quad , \text{ and}$$

$$c_2^2 = N / \sum w^2(k),$$

and N is the number of equally spaced observations, with sampling interval Δt , and samples are for $k=0, \dots, N-1$. In **sacpsd** the user may select either a Hanning window or a 10% sine taper for the windowing function.

Using an N -point discrete Fourier transform (DFT), the transform of $s(k)$ is $S(n)$, which is defined as

$$S(n) = \sum_{k=0}^{N-1} s(k) e^{-j2\pi f t \Delta t} = \sum s(k) e^{-j2\pi n k / N \Delta t}$$

where $n=0, 1, \dots, N-1$. The time and frequency samples are $t = k \Delta t$ and $f = n \Delta f$ where $\Delta f = 1/(N\Delta t)$. Because of the definitions of the forward and inverse Discrete Fourier Transforms (DFT's), both $s(k)$ and $S(n)$ are periodic.

The convention for the power spectrum is to define it as

$$\text{PSD}(f=n f) = 2 S^2(n) / T$$

where the time window $T = N \Delta t$. The factor 2 accounts for the negative frequency contribution.

For actual processing, the initial time series is assumed to consist of more than $N=16384$ points. Then using successive N point segments that overlap by $N/2$ points, the individual PSD's are summed and finally averaged by dividing by the number of segments, NSEG. The stacking and averaging reduces the variance in the PSD estimate, yielding a smoother PSD.

The estimate of the ground noise uses the frequency dependent modulus of acceleration sensitivity of the sensor, $G(\text{counts}/\text{m}/\text{s}^2)$ to give the noise estimate in decibels through the relation

$$N(f) = 10 \log_{10} [(1/\text{NSEG}) \sum \text{PSD}_i / G^2]$$

For comparison with other determinations, a smoothed noise spectrum is computed from

$$(1/\text{NSEG}) \sum \text{PSD}_i / G^2]$$

by applying a simple smoother, currently a 5-point averaging operation in the equi-spaced frequency domain. Other smoothers may be implemented in the future. We note that McNamara and Buland (2004) apply a smoothing operation over period. It will be seen in Figures 3 and 4 that there is a significant difference between the two techniques at certain frequencies. Finally the smoothed noise spectrum is linearly interpolated to yield estimates at periods that are multiples of $2^{1/8}$ and then converted to decibel. To make the output independent of sample rate, the multiples are always with respect to a period of 1.0 seconds. This smoothed version is always plotted as an overlay onto the $N(f)$.

3. Using sacpsd

sacpsd is invoked directly from the command line. The command syntax and options can always be seen by invoking the command as

```
rbh> sacpsd -h
Usage: sacpsd -f sacfile -r response -H -S -L listfile
-f sacfile      (default none) sac binary trace
-r response     (default none) file giving table of
                frequency-response pairs created by invoking
                evalresp with the -u "acc" flag to give the
                amplitude response in units of COUNTS/M/S**2 vs f(Hz)
-H              (default false ) use Hanning window
-S              (default true ) use 10% sin windo
-L listfile     plots according to list which has entries
                psd_file1 kolor1 title1
                psd_file2 kolor2 title2
                where file1 is listing of period-psd(db) pairs
                kolor is a CALPLOT color, e.g., 1000 to 1100 for red ->blue
                title is a string without spaces
-A alistfile   plots according to list which has entries
                psd_file1
                psd_file2
                The color is automatically generated
-NT            (default false ) do not annotate with file name
w
-5             (default true ) apply 5 point PSD smoothing
-h             (default false) online help
```

The output of the program is a CALPLOT graphics file, SACPSD.PLT, and file named using the template NNSSSSSCCCLL.YYYY.DDD.HH.MM.psd, where NN is the network code, SSSSS the station code, CCC the channel code, LL the location, YYYY the year, DDD the day of year, and HH and MM are the hour and minute of the reference time in the header of the Sac formatted traces. Because the display graphics is built into the program, different invocations yield differing results, the previous graphics file, SACPSD.PLT is overwritten.

3.1 Simple examples of using sacpsd

If **sacpsd** is invoked with no arguments, then the resulting plot shows the high- and low-noise models (Peterson, 1993). Note that the **rbh>** is the computer prompt and that the command follows the prompt.

```
rbh> sacpsd
```

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creates the plot file SACPSD.PLT, which can be converted to an EPS file using the command

```
rbh> plotnps -F7 -W10 -EPS -K < SACPSD.PLT > j.eps  
rbh> convert -trim j.eps Fig01.png
```

convert is the ImageMagick program (<http://www.imagemagick.org/>) that convert and/or displays different file formats. The resulting figure is shown in Figure 1.

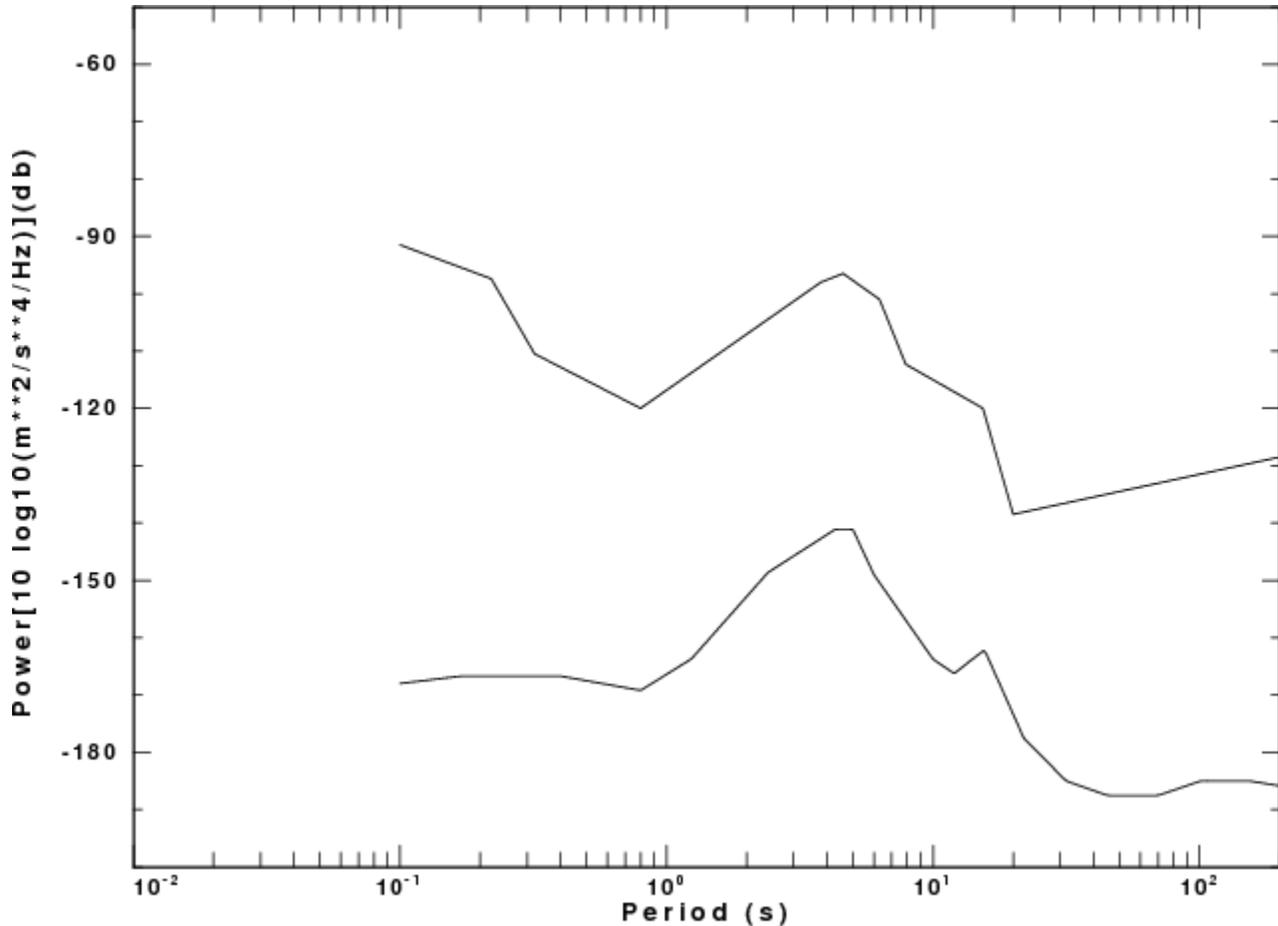


Fig. 1. Default output of **sacpsd** which is just a plot of the low and high noise models

The second example uses a one-hour long BHZ component of the station SLM and the acceleration sensitivity file for that channel:

```
rbh> sacpsd -f NMSLM_BHZ_.SAC -r AMP.NM.SLM_.BHZ  
rbh> plotnps -F7 -W10 -EPS -L < SACPSD.PLT > j.eps  
rbh> convert -trim j.eps Fig02.png
```

which creates the SACPSD.PLT file which is converted to a PNG format, and the file

NMSLM__BHZ__.2009.305.10.59.psd

which is a period – PSD file for the NM network, SLM station, BHZ component for day 305 of 2009 with data set starting at 10:59 UT. The first few lines of this file are

```
197.402986 -144.208
181.019336 -145.028
165.995463 -146.144
152.218511 -146.996
139.584990 -147.991
128.000000 -148.628
117.376518 -149.148
```

Figure 2 shows the resulting plot.

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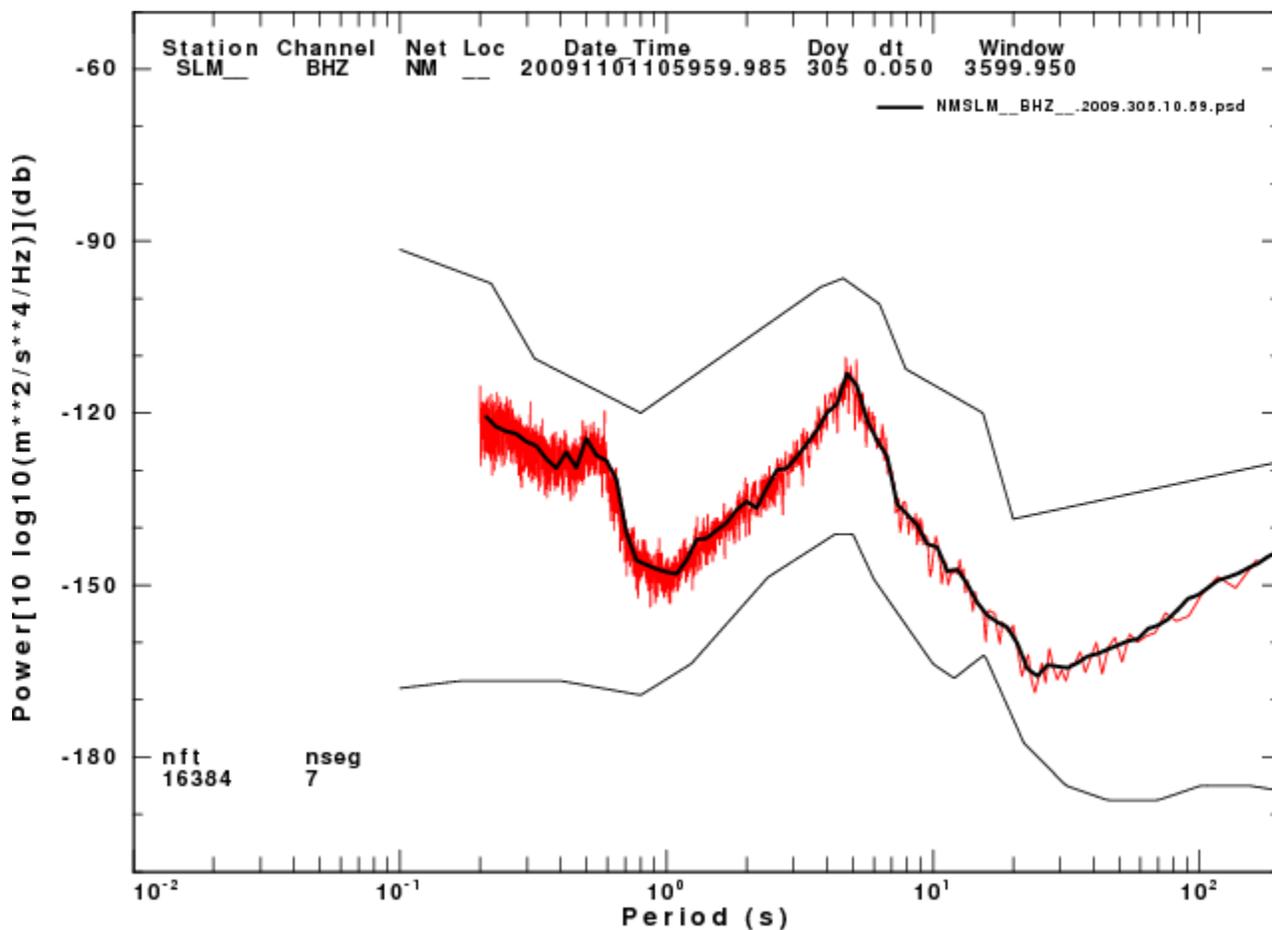


Fig. 2. The computed PSD is plotted in red. The 5-point smoothed PSD is plotted as the thicker black line. The figure is annotated with the reference time contained in the trace header.

The figure is annotated with sufficient information to define the trace. **nft** indicates the length of the Fast Fourier transform used, and **nseg** is the number of individual PSD's that were averaged to yield the red curves above. The larger that **nseg** is, the smoother the red curve, and the more meaningful the average.

The next variation overlays another PSD estimate which is in the file *mxy*, with one period – PSD entry per line. The first few lines of *mxy* are

```
0.616884      -130
0.672717      -130
0.733603      -132
0.800000      -135
0.872406      -141
0.951366      -145
1.037472      -145
```

```
1.131371      -145
```

The control file *listfile.03* consists of just one line:

```
mxy 1080 McNamara
```

This listfile.03 has three entries, the name of the file, an integer representing a CALPLOT color, and a title word. Figure 3 is created using the following command lines:

```
rbh> sacpsd -f NMSLM__BHZ__.SAC -r AMP.NM.SLM..BHZ -L listfile.03
rbh> plotnps -F7 -W10 -EPS -L < SACPSD.PLT > j.eps
rbh> convert -trim j.eps Fig03.png
```

The result of this run is the creation of the PSD file

```
NMSLM__BHZ__.2009.305.10.59.psd
```

and the plot shown in Figure 3.

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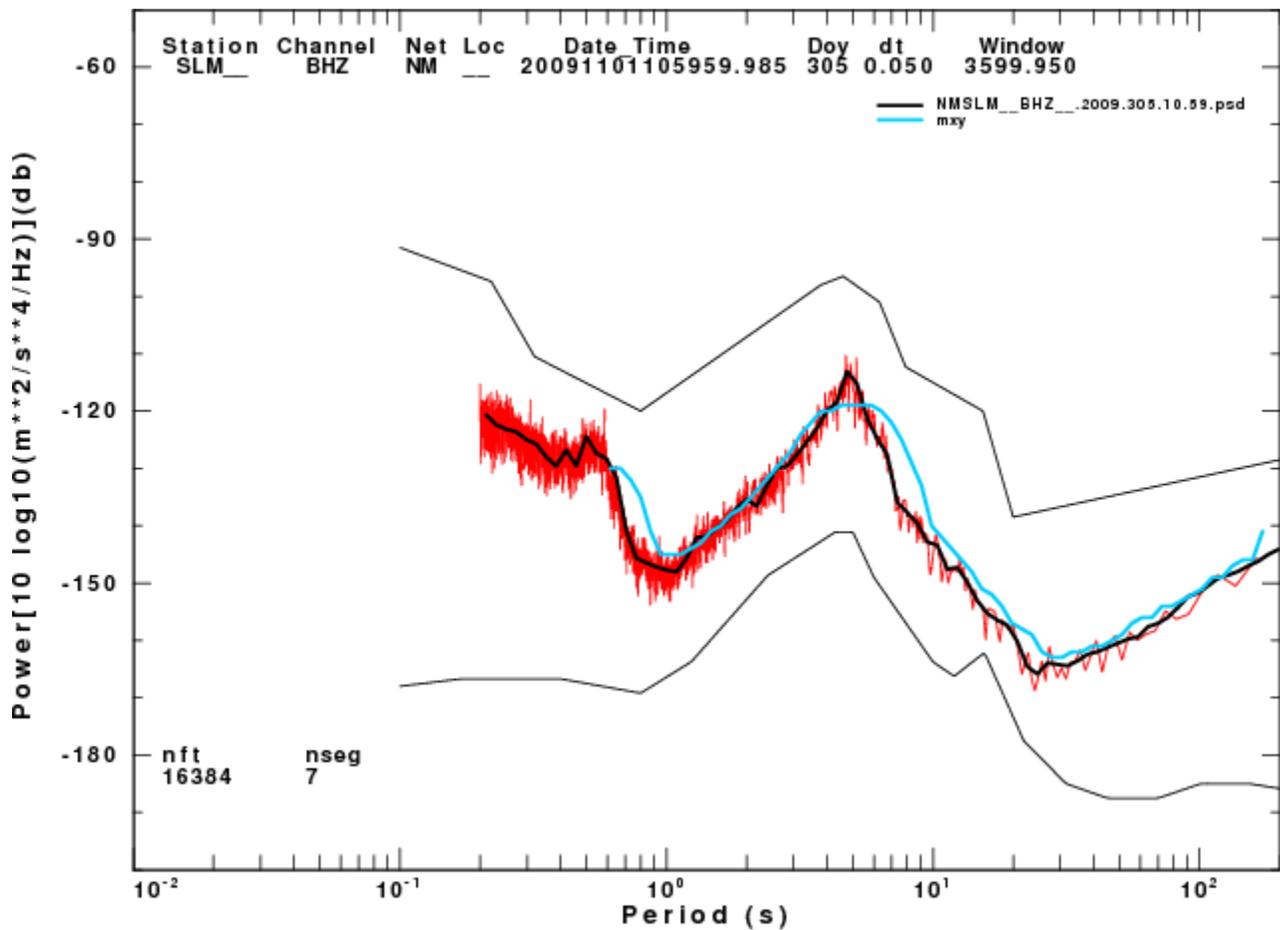


Fig. 3. Overlay of PSD contained in the file *mxy* on top of the computed PSD. The orange curve is from the *sacpsd* computation, while the blue-green curve is the result of running McNamara's program *psd*. The inset gives the name of the listfile.

The final example is to use the file list in the file *listfile.04* which contains the two entries:

```
mxy 1080 McNamara  
NMSLM__BHZ__.2009.305.10.59.psd 1020 SLM
```

with the command sequence

```
rbh> sacpsd -L listfile.04  
rbh> plotnps -F7 -W10 -EPS -K < SACPSD.PLT > j.eps  
rbh> convert -trim j.eps Fig04.png
```

Figure 4 shows the result of using this command.

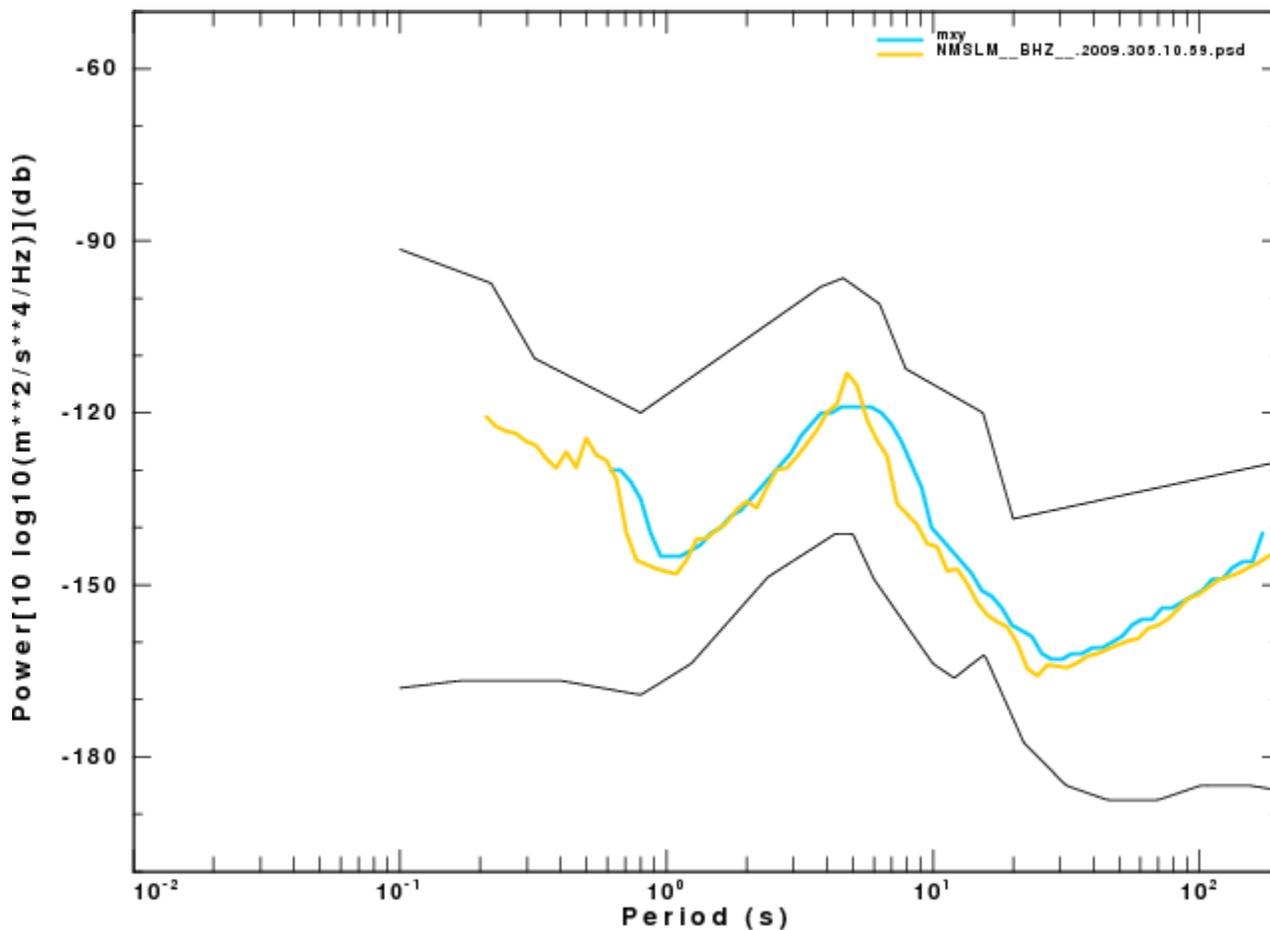


Fig. 4. Example of comparing the contents of PSD files. The orange curve is from the **sacpsd** computation, while the blue-green curve is the result of running the McNamara and Buland (2004) code.

In Figures 3 and 4. we see a major difference between the results of applying the McNamara and Buland (2004) code. To understand the source of this problem, we downloaded an early version from the USGS anonymous ftp site, unpacked it, and compiled to create the program **pdf**. Using the same trace and instrument response, debugging statements showed that all output was identical up to the computation of the smoothed spectrum. **sacpsd** applies a liner average over frequency, while **pdf** averages samples in the period domain between periods T and $2^{1/8} T$, associating the average with a period $2^{1/16} T$. This choice of smoothing introduced a bias in regions where the $N(f)$ changes rapidly. *This difference may appear on all routinely published PSD's that use the original code.*

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3.2 Data from the USGS CWB

The CWB is not a permanent data archive since its purpose is to support the rapid determination of earthquake source parameters. However it contains almost all stations of the USGS supported regional and global networks as well as many open stations operated by other agencies.

CWBQuery (<https://code.usgs.gov/groups/ghsc/neic/-/packages>) and **jmdget** are programs developed by the USGS NEIC to access the Continuous Wave Buffer and station metadata. In the script shown here, we use CWBQuery to obtain one-hour of data from the BHZ components for the NM network for February 7, 2010 starting at 11:00:00 UT.

The example shows how to use the pole-zero files. These are text files with many comments and are to be used with **gsac** or **sac**. Following this there is a short note on how to use the RESP files obtained using **jmdget.jar**.

Note: The pole-zero files obtained using the invocation of CWBQuery have units of (counts/nm). Thus there is a correction factor of 1.0E+09 in the following script.

The processing script is called *DOIT* and is listed here.

3.2.1 Using CWBQuery with pole-zero responses

```
#!/bin/sh

#####
#       define the time windows for the trace and response
#####
DATETIME="2026/03/01-11:00:00"
WINDOW=3600

#####
#       Clean up
#####
rm -f *SAC *SAC.pz *.png *.eps

#####
#       define a short name for CWBQuery
#####
alias query='java -jar ~/bin/CWBQuery.jar'

#####
#       Use query to get all data for NM network filling gaps with
#       zeros, returning as a Sac file.
#       Use mdget to get the RESP file for use with the program
#       evalresp.
#       Note that a line terminated with a backslash newline is
#       a continuation for the shell and is use for clarity
#####
query -dccbgb -t sac -o "%N.SAC" -sacpz nm -fill 0 -b "${DATETIME}" -d ${WINDOW} -s "NM.....HHZ.."

#####
#       perform the PSD
#####

for TRACE in *.SAC
do
```

```
#####
#       get information from the file
#####

KSTNM=`sac1hdr -KSTNM $TRACE`
KCMPNM=`sac1hdr -KCMPNM $TRACE`
DELTA=`sac1hdr -DELTA $TRACE`
NPTS=`sac1hdr -NPTS $TRACE`
FHH=`echo $DELTA | awk '{print 0.50/$1}' `
FHL=`echo $DELTA | awk '{print 0.25/$1}' `
YEAR=`sac1hdr -NZYEAR $TRACE`
DOY=`sac1hdr -NZJDAY $TRACE`
KNETWK=`sac1hdr -KNETWK $TRACE`
KHOLE=`sac1hdr -KHOLE $TRACE`

#####
#       define the lower frequency bound which is 1/4 length off record
#####
FLH=`echo $NPTS $DELTA | awk '{print 1.0/($1*$2)}' `
#####
#       we will not rewrite the KNETWK and KHOLE in the headers with new values
#       we will just repeat the following steps in the script
#####
if [ -z "${KNETWK}" ]
then
    NET=""
else
    if [ "${KNETWK}" = "-12345" ]
    then
        NET=""
    else
        NET="${KNETWK}"
    fi
fi
if [ -z "${KHOLE}" ]
then
    LOC=""
else
    if [ "${KHOLE}" = "-12345" ]
    then
        LOC=""
    else
        LOC="${KHOLE}"
    fi
fi

#####
#       create the acceleration response in terms of M/S**2
#       The comments in the polezero files indicate that the input unit is in nm
#       So there will be a factor of 10.e+9 to get the sensitivity in m
#       Since there is no easy way to get a table of the acceleration response, use
#       gsac
#####
PZFILE=${TRACE}.pz
gsac << EOF
fg imp delta 0.01 npts 16384
w imp.sac
r imp.sac
transfer from acc to polezero subtype $PZFILE
mul 1.0e+9
fft
wsp am
r imp.sac.am
outcsv
```

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```
mv f001.csv ACC.csv
q
EOF
#####
#   now clean up the field to get rid of the header and commas
#   to make a two column file with frequency and acceleration sensitivity
#####
cat ACC.csv | awk -F\, '($0 !~ /^F/){if($1 > 0)print $1, $2 }' > ${TRACE}.accsens

sacpsd -f ${TRACE} -r ${TRACE}.accsens -5

done

ls *psd > afile
sacpsd -A afile
plotnps -K -EPS -F7 -W10 < SACPSD.PLT > t.eps
EPSTOPNG t.eps
mv t.png Fig05.png
rm *.eps
rm SACPSD.PLT

#####
#   final clean up
#####
rm -f *SAC *SAC.pz *SAC.accsens *.psd
```

Figure 5 shows the result of running the script. The final overlay plot shows the high and low noise model limits, and the individual station PSDs. The color coding and long file name provide a means for identifying a curve.

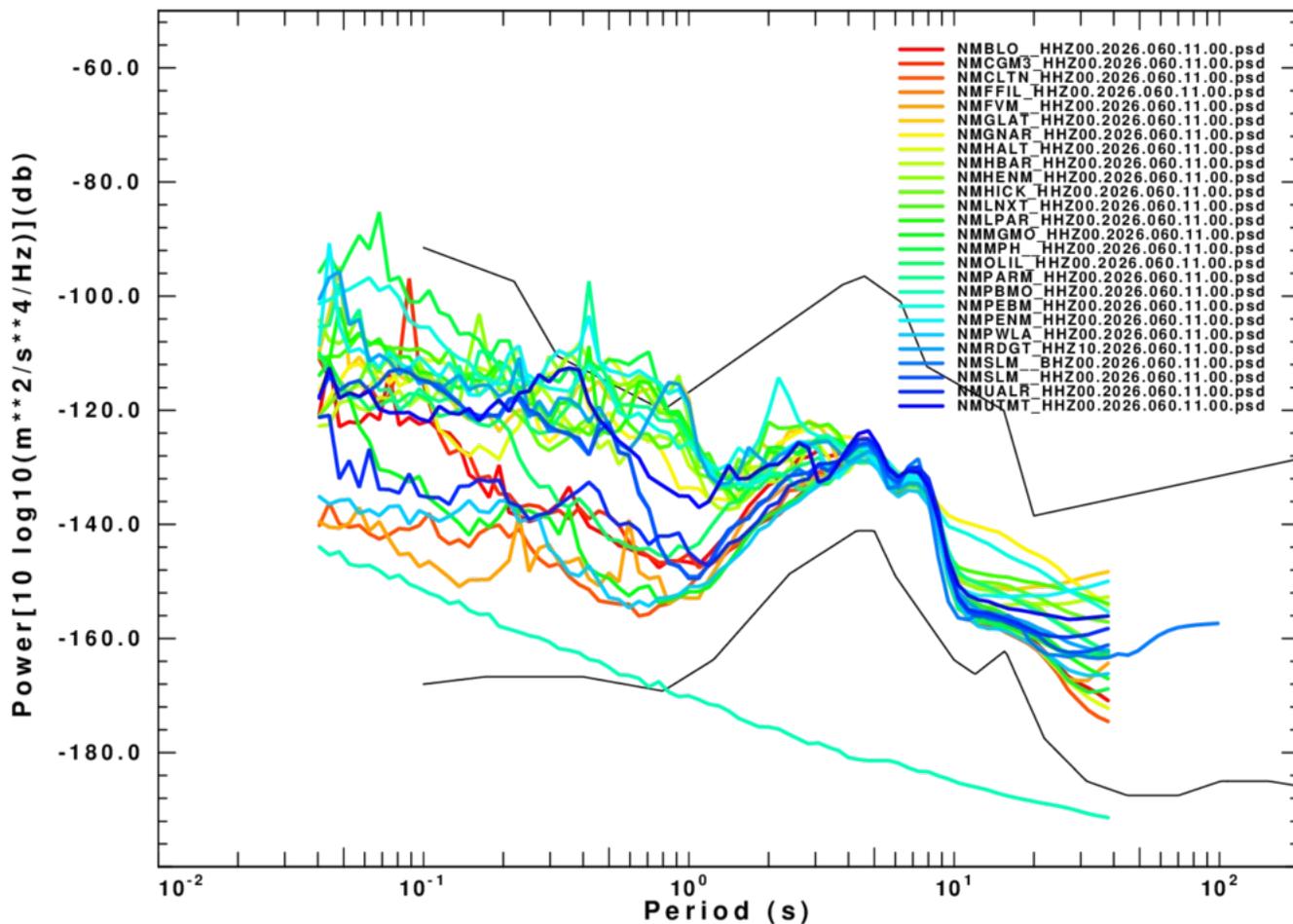


Fig. 5. Result of running the script for the Z component. T

NOTE: Use overlay plots to focus on outliers, which may reflect a) incorrect responses, b) improper instrument performance, or c) major noise differences.

Figure 6 shows the result of changing the script to work with the N and E component at these stations. To do this the line invoking query was changed by replacing "NM.....HHZ.." with "NM.....HH[NE].."

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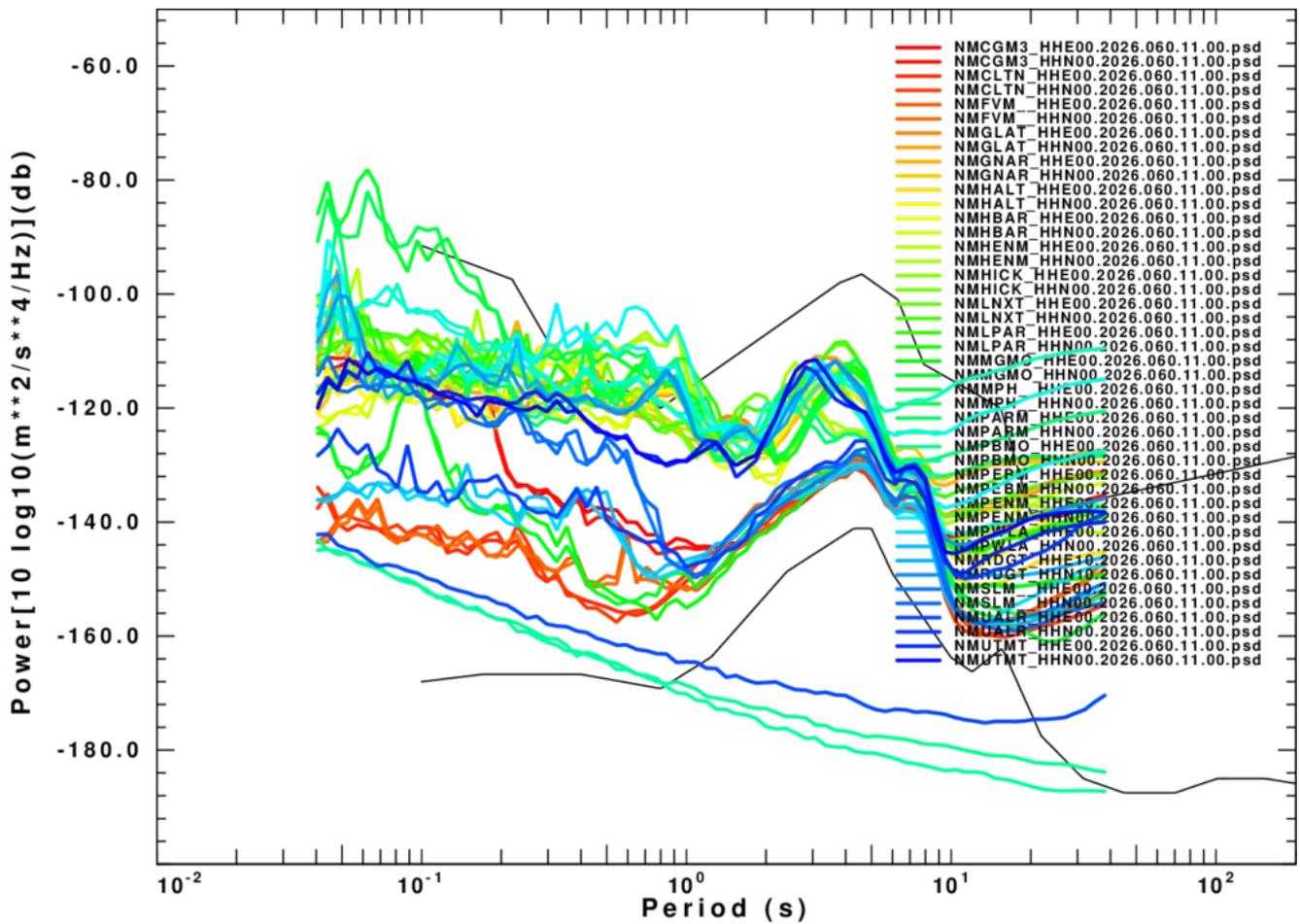


Fig. 6. Running the script used to create Figure 5, but for the N and E components.

The NM stations are in different environments. Some are on hard rock and others are on deep alluvium. As expected the horizontals can be noisier at long periods than the verticals. There are also some pattern seen in Figure 5. After examining the PSD files, we can focus on the horizontal PSD's at a period of 3.0844 s with the following command:

```
rbh$ grep 3.0844 *.psd | sort -nr -k3
NMGLAT_HHN00.2026.060.11.00.psd: 3.084422 -110.937
NMPENM_HHE00.2026.060.11.00.psd: 3.084422 -111.303
NMUTMT_HHN00.2026.060.11.00.psd: 3.084422 -111.481
NMHICK_HHN00.2026.060.11.00.psd: 3.084422 -112.364
NMPENM_HHN00.2026.060.11.00.psd: 3.084422 -112.580
NMGLAT_HHE00.2026.060.11.00.psd: 3.084422 -112.657
NMHICK_HHE00.2026.060.11.00.psd: 3.084422 -112.683
NMLNXT_HHN00.2026.060.11.00.psd: 3.084422 -113.499
NMRDGT_HHE10.2026.060.11.00.psd: 3.084422 -113.572
NMUTMT_HHE00.2026.060.11.00.psd: 3.084422 -113.662
NMRDGT_HHN10.2026.060.11.00.psd: 3.084422 -113.668
NMLNXT_HHE00.2026.060.11.00.psd: 3.084422 -113.734
```

NMPEBM_HHN00.2026.060.11.00.psd:	3.084422	-114.864
NMHALT_HHE00.2026.060.11.00.psd:	3.084422	-115.196
NMHALT_HHN00.2026.060.11.00.psd:	3.084422	-115.308
NMGNAR_HHN00.2026.060.11.00.psd:	3.084422	-115.764
NMPEBM_HHE00.2026.060.11.00.psd:	3.084422	-116.398
NMGNAR_HHE00.2026.060.11.00.psd:	3.084422	-116.872
NMLPAR_HHN00.2026.060.11.00.psd:	3.084422	-118.753
NMHBAR_HHN00.2026.060.11.00.psd:	3.084422	-118.866
NMLPAR_HHE00.2026.060.11.00.psd:	3.084422	-119.225
NMHENM_HHE00.2026.060.11.00.psd:	3.084422	-119.244
NMHBAR_HHE00.2026.060.11.00.psd:	3.084422	-120.160
NMHENM_HHN00.2026.060.11.00.psd:	3.084422	-120.165
NMMPH_HHN00.2026.060.11.00.psd:	3.084422	-120.277
NMMPH_HHE00.2026.060.11.00.psd:	3.084422	-120.675
NMPARM_HHN00.2026.060.11.00.psd:	3.084422	-121.363
NMPARM_HHE00.2026.060.11.00.psd:	3.084422	-123.624
.....		
NMUALR_HHN00.2026.060.11.00.psd:	3.084422	-130.270
NMSLM_HHN00.2026.060.11.00.psd:	3.084422	-130.884
NMFVM_HHN00.2026.060.11.00.psd:	3.084422	-130.998
NMMGMO_HHN00.2026.060.11.00.psd:	3.084422	-132.001
NMPWLA_HHN00.2026.060.11.00.psd:	3.084422	-132.380
NMCGM3_HHN00.2026.060.11.00.psd:	3.084422	-132.838
NMCLTN_HHN00.2026.060.11.00.psd:	3.084422	-132.955
NMSLM_HHE00.2026.060.11.00.psd:	3.084422	-133.099
NMPWLA_HHE00.2026.060.11.00.psd:	3.084422	-133.977
NMMGMO_HHE00.2026.060.11.00.psd:	3.084422	-134.264
NMFVM_HHE00.2026.060.11.00.psd:	3.084422	-134.385
NMCLTN_HHE00.2026.060.11.00.psd:	3.084422	-134.431
NMCGM3_HHE00.2026.060.11.00.psd:	3.084422	-134.652
.....		
NMUALR_HHE00.2026.060.11.00.psd:	3.084422	-169.983
NMPBMO_HHE00.2026.060.11.00.psd:	3.084422	-175.596
NMPBMO_HHN00.2026.060.11.00.psd:	3.084422	-177.869

The dotted lines help focus on patterns seen in the plot. The marker between -123 and -130 db separate stations between those that are not and are on hard rock. The lower marker points out channels that are not functioning correctly.

A plot of the first 300 s of the UALR and PBMO data is given in Figure 7. The PSD of the HHN component at UALR seems OK but the HHE trace is odd. The Sensor is a Trillium and if one of the UVW components is not functioning, then might expect all traces to look odd. Interestingly the raw data stream had the following values:

```

NMUALR_HHE00.SAC (0):
  DEPMAX    -7312878  DEPMIN    -7312919
NMUALR_HHN00.SAC (1):
  DEPMAX     1303    DEPMIN     -479
NMUALR_HHZ00.SAC (2):
  DEPMAX     1357    DEPMIN     -100

```

Internally, the UVW is converted to a ZNE. Perhaps the sensor has a problem in this conversion. After removing a DC trend, the amplitudes of the PBMO components were roughly ± 8 counts, which may be

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typical A/D noise if the sensor has failed.

This

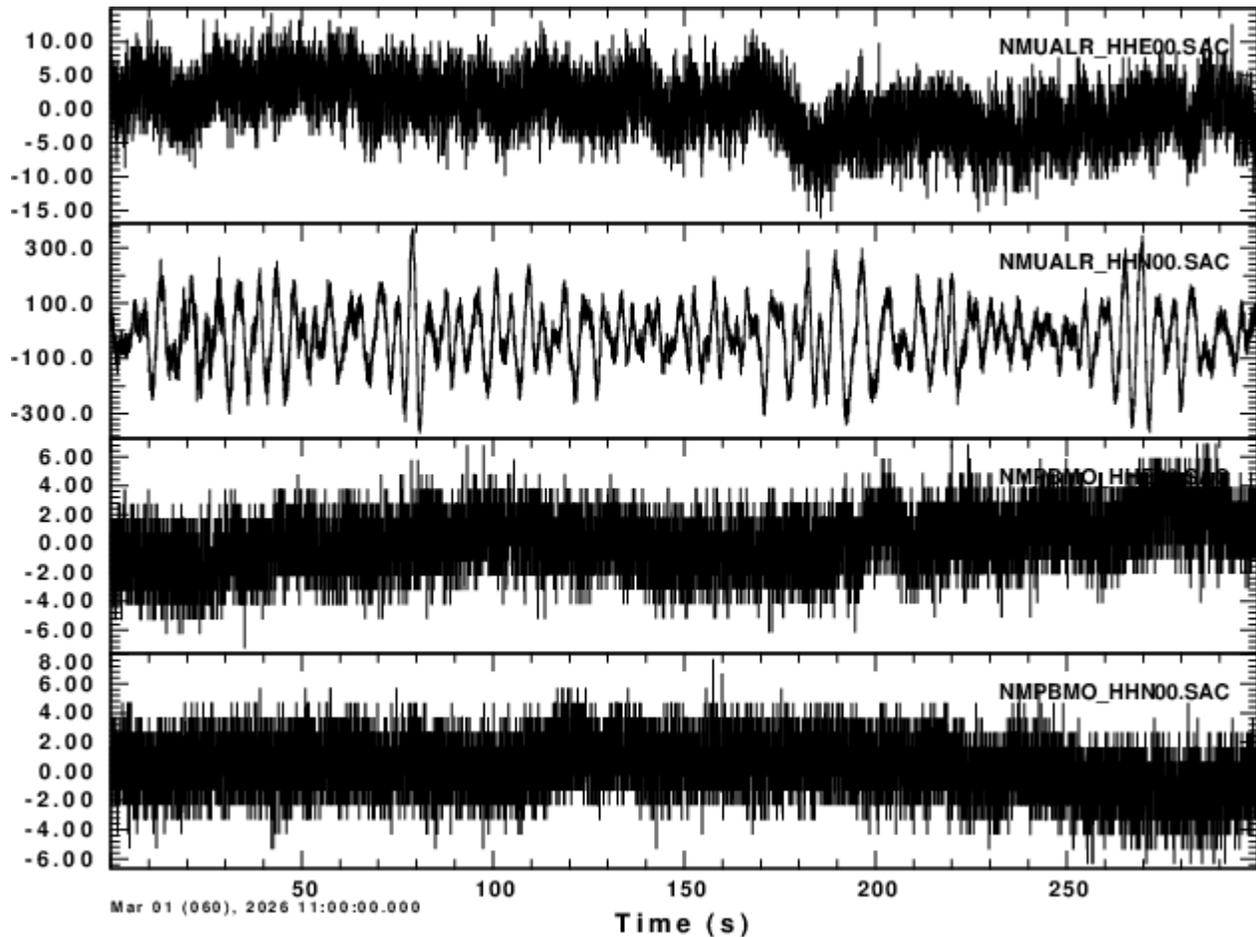


Fig. 7. Plot of traces which had extreme PSD's

Vi 3.2.1 Using CWBQuery with RESP files and evalresp

The processing script is contained in the SACPSD/FIGURE08 directory. There you will find a DOITpz which obtained the PSD using the pole-zero fiels and the DOITresp which uses the RESP files. Finally there is a DOALL which invokes all and overlays the results of each. This is a test of the equivalence of the two techniques. The results are effectively the same. For example at a period of 8.0 s, the PSD's are

```
PZ/NMSLM_HHZ00.2026.060.11.00.psd: 8.000000 -132.686
RSP/NMSLM_HHZ00.2026.060.11.00.psd: 8.000000 -132.693
```

The overlay plot is

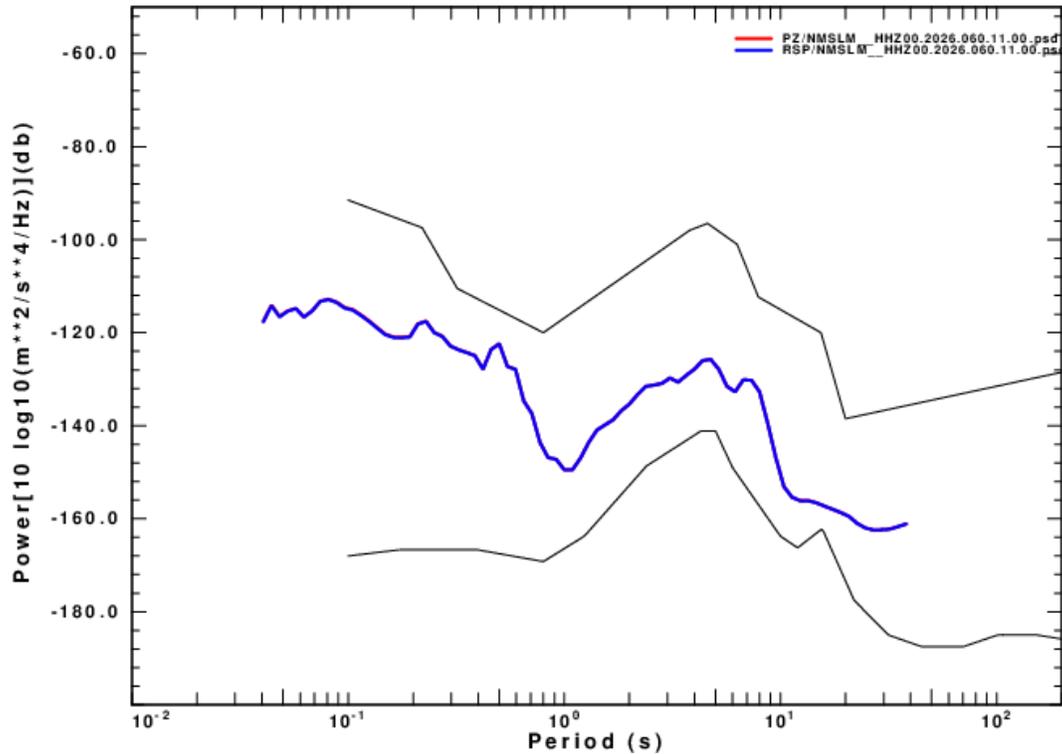


Fig. 8. Overlay of PSD's obtained using pole-zero and RESP files

Rather than listing the entire DOITresp shell script, the major change was to use

```
alias query='java -jar ~/bin/CWBQuery.jar'
alias mdget='java -jar ~/bin/jmdget.jar'

query -dccdbg -t sac -o "%N.SAC" -sacpz nm -fill 0 -b "${DATETIME}" -d ${WINDOW} -s
"NMSLM..HHZ.."
mdget -resp -b ${MDBEG} -e ${MDEND} -s "NMSLM..HHZ.."
. . . .
RESPFILE=RESP.${NET}.${KSTNM}.${LOC}.${KCOMPNM}
#####
# create the acceleration response in terms of M/S**2
# using evalresp for this date.
```

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```
#####
evalresp ${KSTNM} ${KCOMPNM} ${YEAR} ${DOY} ${FLH} ${FHH} 2049 \
-u 'acc' -f ${RESPFILE}
sacpsd -f ${TRACE} -r AMP.${NET}.${KSTNM}.${LOC}.${KCOMPNM} -5
```

3.3 Examples using FDSN access

The International Federation of Digital Seismograph Networks (FDSN) sets standards for the archiving of seismic data. It consists of seismic networks with unique network codes. Some of the networks maintain data centers – <https://www.fdsn.org/datacenters/>. These data centers provide through web services. SEED and StationXML are the formats used for data exchange. These web services are

fdns-station	Access to station metadata
fdns-ndataselect	Access to time series data in miniSEED
fdns-ndevent	Access to event parameters in QuakeML
fdns-availability	Access to time series availability

Some data centers do not provide all services. In the discussion that follows, Section 3.3.4 will demonstrate how to obtain time series and metadata using the FDSN webservice using **wget** or **curl**. In some cases, it may be simpler to use the EarthScope perl script **FetchData**, which is illustrated in Sections 3.3.1 – 3.3.3.

3.3.1 FetchData

FetchData is a **perl** script available from EarthScope that can be used to access seismic data at the EarthScope Data Management center, or other data centers.

Of note are the comment line options *-sd* . *-rd* . which will create the Sac pole-zero and the RESP file for each channel downloaded. The period after the *-sd* and *-rd* indicate that the responses are placed in the current directory. In the example here, these files are named SACPZ.NM.SLM.00.HHZ and RESP.NM.SLM.00.HHZ. In addition **evalresp** is used to obtain the acceleration sensitivity.

The results of executing this example are shown in Figure 9.

```
#!/bin/sh
#####
#   clean up
#####
rm -f *SAC RESP* SACPZ*

#####
#   define the time windows for the trace and response
#####
START="2026-03-01,11:00:00"
END="2026-03-01,12:00:00"
```

```

WINDOW=3600

#####
#       Clean up
#####

FetchData -s ${START} -e ${END} -S 'SLM' -N 'NM' -C 'HHN,HHE,HHZ' -L '*' -sd . -rd .
-m meta -X xml -o miniseed
mseed2sac -m meta -f 2 miniseed

#####
#       meta contains station coordinates and channel orientations
#       xml is the TDSN station xml
#       miniseed contains the waveforms
#
#       The result will be files with names such as
#       NM.SLM.00.HHN.M.2026.060.110000.SAC  RESP.NM.SLM.00.HHN  SACPZ.NM.SLM.00.HHN
#####

#####
#       perform the PSD
#####

for TRACE in *.SAC
do

#####
#       get information from the file
#####

KSTNM=`sac1hdr -KSTNM $TRACE`
KCMPNM=`sac1hdr -KCMPNM $TRACE`
DELTA=`sac1hdr -DELTA $TRACE`
NPTS=`sac1hdr -NPTS $TRACE`
FHH=`echo $DELTA | awk '{print 0.50/$1}'`
FHL=`echo $DELTA | awk '{print 0.25/$1}'`
YEAR=`sac1hdr -NZYEAR $TRACE`
DOY=`sac1hdr -NZJDAY $TRACE`
KNETWK=`sac1hdr -KNETWK $TRACE`
KHOLE=`sac1hdr -KHOLE $TRACE`

#####
#       define the lower frequency bound which is 1/4 length off record
#####
FLH=`echo $NPTS $DELTA | awk '{print 1.0/($1*$2)}'`
#####
#       we will not rewrite the KNETWK and KHOLE in the headers with new values
#       we will just repeat the following steps in the script
#####
if [ -z "${KNETWK}" ]
then
    NET=""
else
    if [ "${KNETWK}" = "-12345" ]
    then
        NET=""
    else

```

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```

                                NET="{KNETWK}"
                                fi
                                fi
                                if [ -z "${KHOLE}" ]
                                then
                                LOC=""
                                else
                                if [ "${KHOLE}" = "-12345" ]
                                then
                                LOC=""
                                else
                                LOC="${KHOLE}"
                                fi
                                fi
                                #####
                                # we know the response file now
                                #####
                                RESPFILE=RESP.${NET}.${KSTNM}.${LOC}.${KCOMPNM}
                                #####
                                # create the acceleration response in terms of M/S**2
                                # using evalresp for this date.
                                #####
                                evalresp ${KSTNM} ${KCOMPNM} ${YEAR} ${DOY} ${FLH} ${FHH} 2049 \
                                -u 'acc' -f ${RESPFILE}
                                #####
                                # now clean up the field to get rid of the header and commas
                                # to make a two column file with frequency and acceleration sensitivity
                                #####
                                sacpsd -f ${TRACE} -r AMP.${NET}.${KSTNM}.${LOC}.${KCOMPNM} -5
                                done

                                ls *psd > afile
                                sacpsd -A afile
                                plotnps -K -EPS -F7 -W10 < SACPSD.PLT > t.eps
                                convert -trim t.eps -background white -alpha remove -alpha off t.png
                                mv t.png Fig09.png
                                rm -f t.eps SACPSD.PLT

                                #####
                                # final clean up
                                #####
                                rm -f *SAC *SAC.pz *SAC.accsens
                                rm -f CC.csv ccsens afile imp.sac imp.sac.am sacpsd.out
                                rm AMP* PHASE* RESP*
                                rm -f *.psd
                                rm -fr meta miniseed
                                rm -f SACPZ*
                                rm -f xml
```

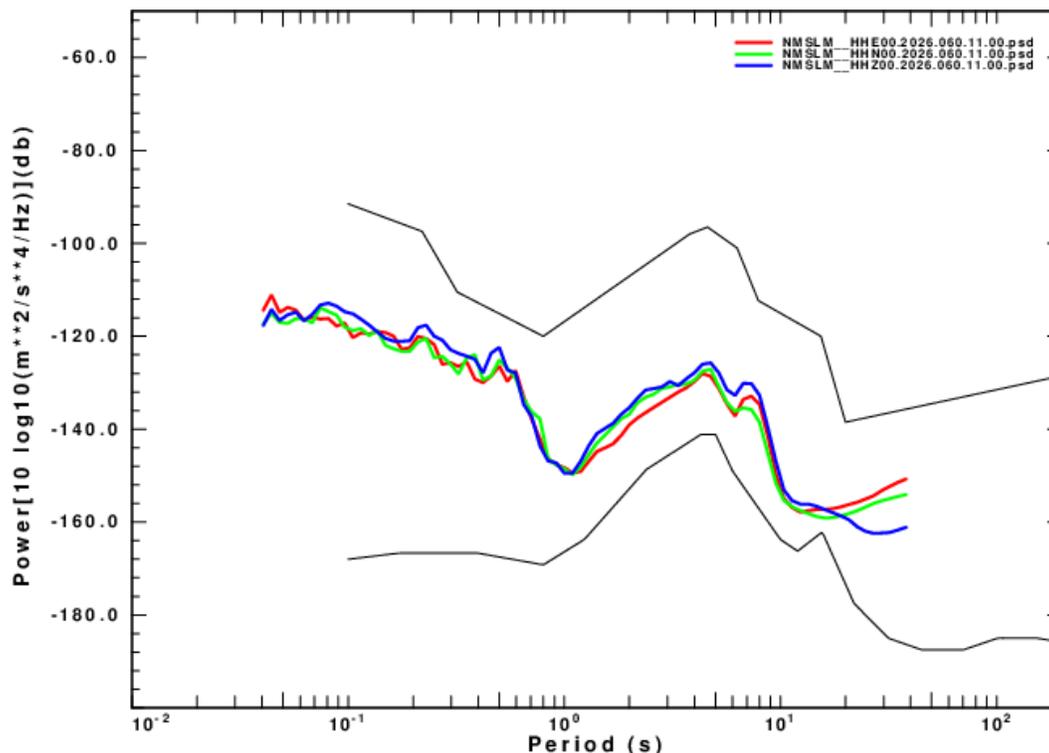


Fig. 9. Noise analysis using FetchData script.

3.3.2 FetchData -F

This is one of the options of FetchData. This is used **ALSO** search for waveforms from other data centers. Thus if we so examine the station BLY of the MN network, one would put

```
-F -S 'BLY' -N 'MN'
```

on the command line. Since the data from this station is available from the INGV data center, the `-rd . -sd .` will not give the responses. Instead the `-X xml` is used to get the FDSN station XML. The EarthScope program `xml2resp` is used to make a big response file that is used with `evalresp` get the responses.

NOTE: Many data centers will NOT support the `-sd` or `-rd` command line options.

The script to get the PSD is only slightly changed from the previous example. It is given here:

Computer Programs in Seismology - sacpsd

```
#!/bin/sh

#####
#   clean up
#####
rm -f *SAC RESP* SACPZ*
rm -f RESPall

#####
#   define the time windows for the trace and response
#####
START="2026-03-01,11:00:00"
END="2026-03-01,12:00:00"
WINDOW=3600

#####
#   Clean up
#####

#####
#   there is no guarantee that the remote data center will provide poelzero of RESP
files
#####
FetchData -F -s ${START} -e ${END} -S 'BLY' -N 'MN' -C 'HHN,HHE,HHZ' -L '*' . -m meta
-X xml -o miniseed

for i in *miniseed
do
    B=`basename $i "-miniseed" `
    mseed2sac -m ${B}-meta -f 2 ${B}-miniseed
    xml2resp -o ${B}-resp ${B}-xml
    cat ${B}-resp >> RESPall
done

#####
#   meta contains station coordinates and channel orientations
#   xml is the TDSN station xml
#   miniseed contains the waveforms
#
#   The result will be files with names such as
#   NM.SLM.00.HHN.M.2026.060.110000.SAC RESP.NM.SLM.00.HHN SACPZ.NM.SLM.00.HHN
#####

#####
#   perform the PSD
#####

for TRACE in *.SAC
do

#####
#   get information from the file
#####

KSTNM=`saclhdr -KSTNM $TRACE`
KCOMPNM=`saclhdr -KCOMPNM $TRACE`
DELTA=`saclhdr -DELTA $TRACE`
```

```

NPTS=`sac1hdr -NPTS $TRACE`
FHH=`echo $DELTA | awk '{print 0.50/$1}' `
FHL=`echo $DELTA | awk '{print 0.25/$1}' `
YEAR=`sac1hdr -NZYEAR $TRACE`
DOY=`sac1hdr -NZJDAY $TRACE`
KNETWK=`sac1hdr -KNETWK $TRACE`
KHOLE=`sac1hdr -KHOLE $TRACE`

#####
#   define the lower frequency bound which is 1/4 length off record
#####
FLH=`echo $NPTS $DELTA | awk '{print 1.0/($1*$2)}' `
#####
#   we will not rewrite the KNETWK and KHOLE in the headers with new values
#   we will just repeat the following steps in the script
#####
if [ -z "${KNETWK}" ]
then
    NET=""
else
    if [ "${KNETWK}" = "-12345" ]
    then
        NET=""
    else
        NET="${KNETWK}"
    fi
fi
if [ -z "${KHOLE}" ]
then
    LOC=""
else
    if [ "${KHOLE}" = "-12345" ]
    then
        LOC=""
    else
        LOC="${KHOLE}"
    fi
fi

#####
#   we know the response file now
#####
RESPFILE=RESPall
#####
#   create the acceleration response in terms of M/S**2
#   using evalresp for this date.
#####
evalresp ${KSTNM} ${KCMPNM} ${YEAR} ${DOY} ${FLH} ${FHH} 2049 \
    -u 'acc' -f ${RESPFILE}

#####
#   now clean up the field to get rid of the header and commas
#   to make a two column file with frequency and acceleration sensitivity
#####
sacpsd -f ${TRACE} -r AMP.${NET}.${KSTNM}.${LOC}.${KCMPNM} -5

done
ls *psd > afile
sacpsd -A afile

```

Computer Programs in Seismology - sacpsd

```
plotnps -K -EPS -F7 -W10 < SACPSD.PLT > t.eps
convert -trim t.eps -background white -alpha remove -alpha off t.png
mv t.png Fig10.png
```

```
#####
#   final clean up
#####
rm -f *SAC *SAC.pz *SAC.accsens
rm -f CC.csv ccsens afile imp.sac imp.sac.am sacpsd.out
rm AMP* PHASE* RESP*
rm -f *.psd
```

Figure 10 shows the resulting plot.

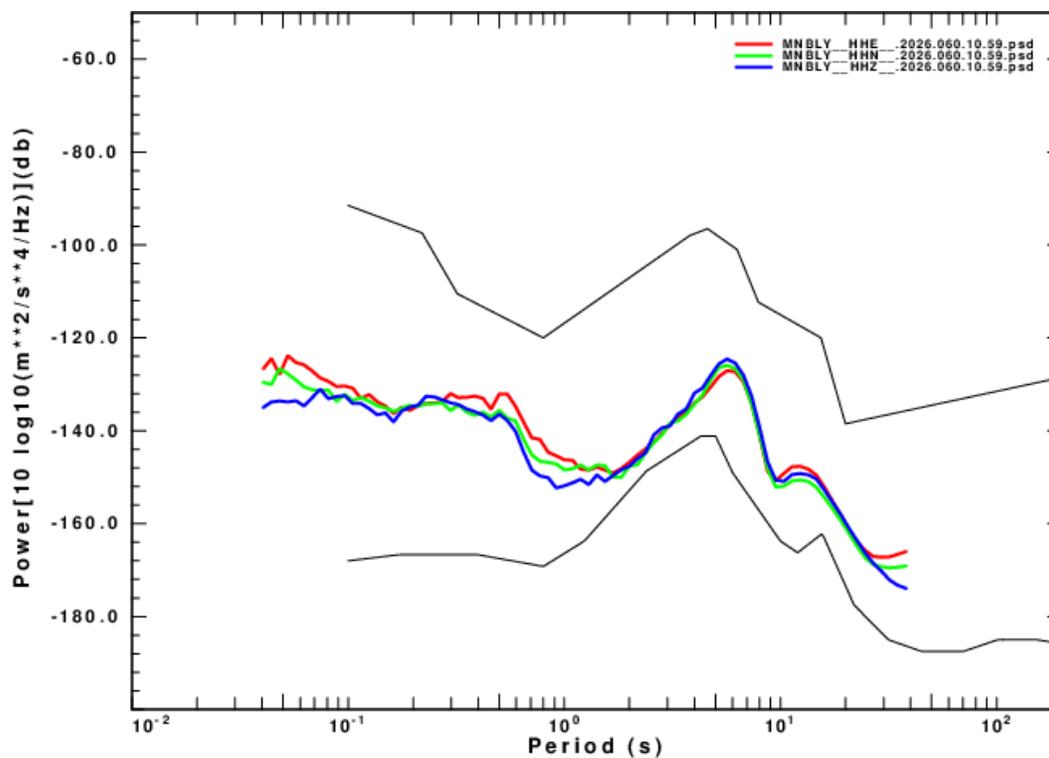


Fig. 10. Example of the use of FetchData -F

NOTE: Many data centers will NOT support the -sd or -rd command line options.

A second example performs the noise analysis on all HH channels of the CA network operated by the [Institut Cartogràfic i Geològic de Catalunya](#). This is accomplished by changing the line with the FetchData command of the previous script to

```
NET="CA"
FetchData -F -s ${START} -e ${END} -S '*' -N ${NET} -C 'HHN,HHE,HHZ' -L '*' -m meta -X xml -o miniseed
```

The figure produced is

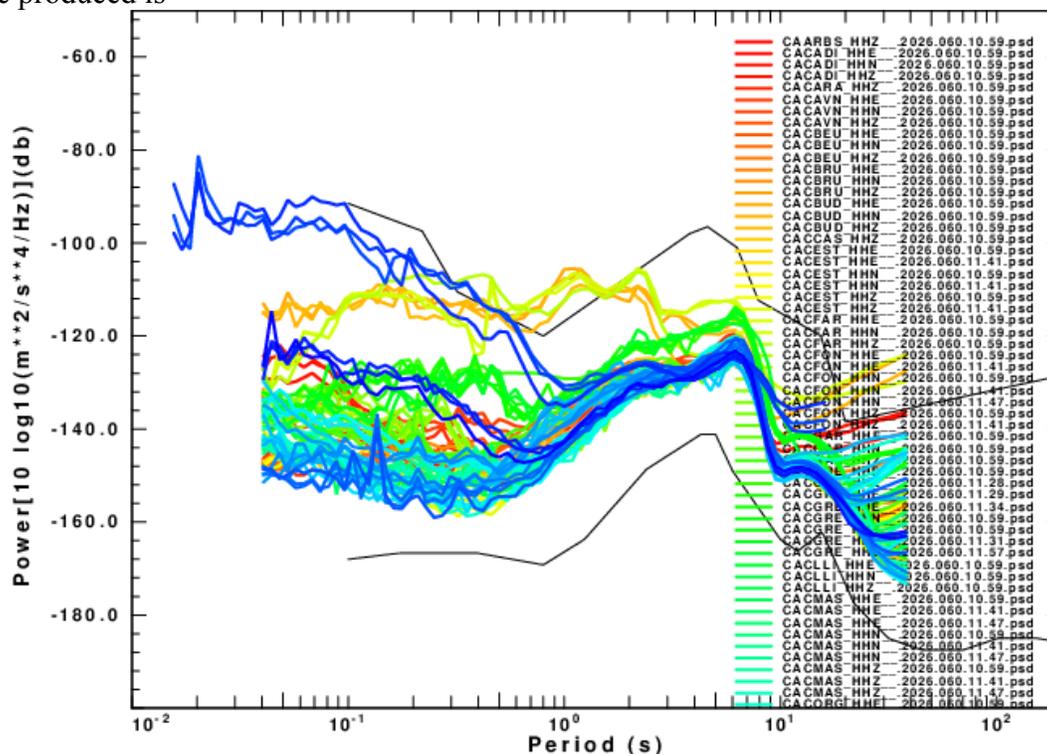


Fig. 11. Noise analysis of the CA network.

3.3.3 FetchData (RaspberryShake)

RaspberryShake data are available using the FDSN Fetch Services. The network description is found at <https://www.fdsn.org/networks/detail/AM/>. The RaspberryShake is a high frequency sensor that has some longer period response through internal signal processing with the result that the velocity sensitivity is flat in the range 0.5 – 50 Hz. The RB8BB sensor is in my home.

The script to create Figure 12 differs only in the initial part. It uses a shell environment parameter to pass the name of the webservice to FetchData. These lines are

Computer Programs in Seismology - sacpsd

```
#!/bin/sh

#####
#   clean up
#####
rm -f *SAC RESP* SACPZ*
rm -f RESPall

export SERVICEBASE='https://data.raspberrypi.org'
NET="AM"
echo $SERVICEBASE

#####
#   define the time windows for the trace and response
#####
START="2026-03-15,11:00:00"
END="2026-03-15,12:00:00"
WINDOW=3600

#####
#   Clean up
#####

#####
#   there is no guarantee that the remote data center will provide poelzero of RESP files
#####
FetchData -s ${START} -e ${END} -S 'RB8BB' -N ${NET} -C '*' -L '*' -m meta -X xml -o miniseed

    mseed2sac -m meta -f 2 miniseed
    xml2resp -o resp xml
    cat resp >> RESPall
```

The noise plot is shown in Figure 12. The sensor is in the basement of a home. The noise at long periods is due to low sensitivity at these periods. The noise at periods less than 5 sec is not too bad for a sensor that is not at a quiet observatory.

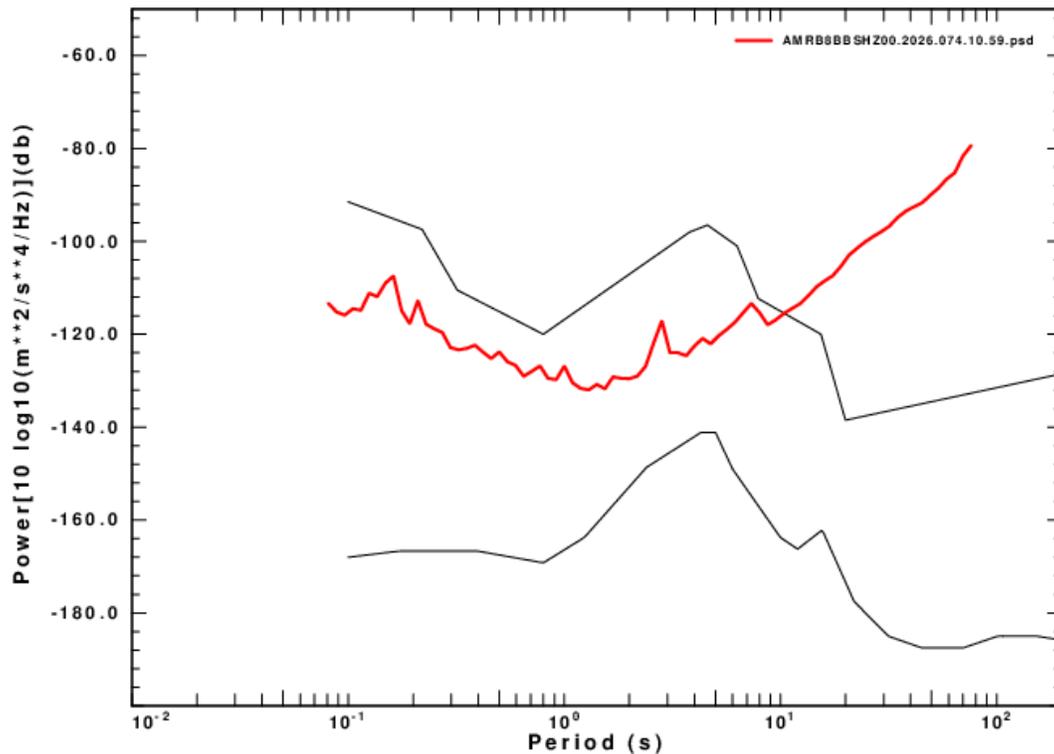


Fig. 12. RB8BB noise using one hour of noise.

3.3.4 Use of wget/curl

As mentioned above, **FetchData** is a higher level front-end to the fdsnws-station and fdsnws-dataselect services.

Rather than providing a complete shell script that acquires the responses and time series, and then obtains the PSD's, this section will give some examples of how to use the FDSN web services.

The first example shows the use of **wget** to get station information and then later to get the waveforms. The script is shown in Figure 13. You will note that much more detail is required than when using **FetchData**.

Computer Programs in Seismology - sacpsd

```
#!/bin/sh

#####
# This script is based on the work of Dr. Antonio Villasenor
# use the ICGC data center
#####
SERVICEBASE="https://ws.icgc.cat"

/bin/rm -f icgc*

lat0=41.7188
lon0=-1.7851
maxradius=3.0

starttime="2023-09-26T13:15:20.97"
endtime="2023-09-26T13:18:20.97"

# get available channels during day of the event
wget -O icgc_channels.txt "${SERVICEBASE}/fdsnws/station/1/query?starttime=${starttime}&endtime=${endtime}&latitude=${lat0}&longitude=${lon0}&maxradius=${maxradius}&level=channel&format=text&formatted=true&nodata=404"

# get station metadata for available channels in stationXML format
wget -O icgc.xml "${SERVICEBASE}/fdsnws/station/1/query?starttime=${starttime}&endtime=${endtime}&latitude=${lat0}&longitude=${lon0}&maxradius=${maxradius}&level=channel&format=xml&formatted=true&nodata=404"

# reformat channel txt file to POST file
awk -F\| '($0 !~ /^#/)' {printf("%-2s %-6s * %-3s %-s %-s\n", $1, $2, $4, starttime, endtime)}'
starttime=$starttime endtime=$endtime icgc_channels.txt > icgc.post

# optionally remove unwanted channels from POST file (accelerometers, short periods, etc)

# request waveform data
wget --post-file=icgc.post -O icgc.miniseed ${SERVICEBASE}/fdsnws/dataselect/1/query

# use mseed2sac to create Sac files
mseed2sac -m icgc_channels.txt -f 2 icgc.miniseed

# create the RESP files
xml2resp -o icgc.RESP icgc.xml

# Use the RESP with evalresp or use the icgc.xml with evalresp
```

Fig. 13. Example of using FDSN web services directly.

The next example shows the syntax of using **wget** and **curl** to perform the same request. Here the station XML is requested for a specific geographical region. The original **curl** was provided by Stefano Pintore of INGV:

```
#!/bin/sh

wget -O wa.xml "https://webservices.ingv.it/fdsnws/station/1/query?format=xml&level=response&starttime=2025-10-19T22:59:00.0&endtime=2025-10-19T23:02:00.0&minlat=38.45&maxlat=42.45&minlon=17.85&maxlon=21.85"
(base) compaq: ACCESS rbh$ cat DOCURL

curl -o a.xml "https://webservices.ingv.it/fdsnws/station/1/query?format=xml&level=response&starttime=2025-10-19T22:59:00.0&endtime=2025-10-19T23:02:00.0&minlat=38.45&maxlat=42.45&minlon=17.85&maxlon=21.85"
```

The final example from Stefano uses a searches for all stations within a radius about a given location. He mentions that this is much slower than by searching for all stations within a a bounding box:

```
curl -o /tmp/a.dat "https://webservices.ingv.it/fdsnws/station/1/query?
format=xml&level=response&starttime=2025-10-19T22:59:00.0&endtime=2025-10-
19T23:02:00.0&minlat=38.45&maxlat=42.45&minlon=17.85&maxlon=21.85"
```

4.0 References

- Ileachor, E. C., and B. W. Jervis (1993). *Digital Signal Processing: A Practical Approach*, Addison Wesley, Wokingham, England, 760pp
- McNamara, D. E., and R. P Buland (2004). Ambient noise levels in the continental United States, *Bull. Seism. Soc. Am.* **94**, 1517-1527.
- Peterson, J. (1993). Observation and modeling of seismic background noise, *U. S. Geol. Surv. Tech. Rept.* 93-322, 1-95.

Appendix

A – FDSN Web Services

This information is extracted from <https://www.fdsn.org/webservices/fdsnws-station-1.1.pdf> and <https://www.fdsn.org/webservices/fdsnws-dataselect-1.1.pdf>. Table 1 of each document is duplicated here for reference.

Computer Programs in Seismology - sacpsd

A.1 data select

Table 1. Parameters for the *query* method:

Parameter	Alias	Support	Default	Allowed Values	Type	Unit
starttime	start	required	[Any]	Any valid time	time	UTC
	Limit results to time series samples on or after the specified start time					
endtime	end	required	[Any]	Any valid time	time	UTC
	Limit results to time series samples on or before the specified end time					
network	net	required	[Any]	Valid network code or wildcard	string	
	Select one or more network codes. Can be SEED network codes or data center defined codes. Multiple codes are comma-separated.					
station	sta	required	[Any]	Valid station code or wildcard	string	
	Select one or more SEED station codes. Multiple codes are comma-separated.					
location	loc	required	[Any]	Valid location code or wildcard	string	
	Select one or more SEED location identifiers. Multiple identifiers are comma-separated. As a special case '--' (two dashes) will be translated to a string of two space characters to match blank location IDs.					
channel	cha	required	[Any]	Valid channel code or wildcard	string	
	Select one or more SEED channel codes. Multiple codes are comma-separated.					
quality		optional	B	D, R, Q, M or B	string	
	Select a specific SEED quality indicator, handling is data center dependent.					
minimumlength		optional	0.0	>= 0.0	float	
	Limit results to continuous data segments of a minimum length specified in seconds.					
longestonly		optional	FALSE	TRUE or FALSE	boolean	
	Limit results to the longest continuous segment per channel.					
format		optional	miniseed	miniseed	string	
	Specify format of result, the default value is <i>miniseed</i> . If this parameter is not specified the service must return miniSEED.					
nodata		optional	204	204 or 404	string	
	Select status code for "no data", either 204 (default) or 404 .					

A.2 station

Table 1. Parameters for the *query* method:

Parameter	Alias	Support	Default	Allowed Values	Type	Unit
starttime	start	required	[Any]	Any valid time	time	UTC
					Limit results to time series samples on or after the specified start time.	
endtime	end	required	[Any]	Any valid time	time	UTC
					Limit results to time series samples on or before the specified end time.	
startbefore		optional	[Any]	Any valid time	time	UTC
					Limit to metadata epochs starting before specified time.	
startafter		optional	[Any]	Any valid time	time	UTC
					Limit to metadata epochs starting after specified time.	
endbefore		optional	[Any]	Any valid time	time	UTC
					Limit to metadata epochs ending before specified time.	
endafter		optional	[Any]	Any valid time	time	UTC
					Limit to metadata epochs ending after specified time.	
network	net	required	[Any]	Valid network code or wildcard	string	
					Select one or more network codes. Can be FDSN network codes or data center defined codes. Multiple codes are comma-separated.	
station	sta	required	[Any]	Valid station code or wildcard	string	
					Select one or more FDSN station codes. Multiple codes are comma-separated.	
location	loc	required	[Any]	Valid location code or wildcard	string	
					Select one or more FDSN location identifiers. Multiple identifiers are comma-separated. As a special case '--' (two dashes) will be translated to a string of two space characters to match blank location IDs.	
channel	cha	required	[Any]	Valid channel code or wildcard	string	
					Select one or more FDSN channel codes. Multiple codes are comma-separated.	
minlatitude	minlat	required	-90.0	-90.0 to 90.0	float	degrees
					Limit to stations with a latitude larger than or equal to the specified minimum.	
maxlatitude	maxlat	required	90.0	-90.0 to 90.0	float	degrees
					Limit to stations with a latitude smaller than or equal to the specified maximum.	
minlongitude	minlon	required	-180.0	-180.0 to 180.0	float	degrees
					Limit to stations with a longitude larger than or equal to the specified minimum.	
maxlongitude	maxlon	required	108.0	-180.0 to 180.0	float	degrees
					Limit to stations with a longitude smaller than or equal to the specified maximum.	

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maxlongitude	maxlon	required	108.0	-180.0 to 180.0	float	degrees
Limit to stations with a longitude smaller than or equal to the specified maximum.						
latitude	lat	optional	0.0	-90.0 to 90.0	float	degrees
Specify the latitude to be used for a radius search.						
longitude	lon	optional	0.0	-180.0 to 180.0	float	degrees
Specify the longitude to be used for a radius search.						
minradius		optional	0.0	0 to 180.0	float	degrees
Limit results to stations within the specified minimum number of degrees from the geographic point defined by the latitude and longitude parameters.						
maxradius		optional	180.0	0 to 180.0	float	degrees
Limit results to stations within the specified maximum number of degrees from the geographic point defined by the latitude and longitude parameters.						
level		required	station	network, station, channel, response	string	
Specify the level of detail for the results.						
includerestricted		optional	TRUE	TRUE or FALSE	boolean	
Specify if results should include information for restricted stations.						
includeavailability		optional	FALSE	TRUE or FALSE	boolean	
Specify if results should include information about time series data availability.						
updatedafter		optional*	[Any]	Any valid time	time	UTC
Limit to metadata updated after specified time; updates are data center specific. * While this option is not required it is highly recommended due to usefulness.						
matchtimeseries		optional	FALSE	TRUE or FALSE	boolean	
Limit to metadata where selection criteria matches time series data availability.						
format		optional	text	xml, text	string	
Specify format of result, either <i>xml</i> (default) or <i>text</i> (defined below). If this parameter is not specified the service must return StationXML.						
nodata		optional	204	204 or 404	string	
Select status code for "no data", either 204 (default) or 404 .						

B – Calplot graphics

B.1 Introduction

Computer Programs in Seismology is distributed with its own graphics package to make the installation of the distributed software easier. Each non-interactive graphics program will create a binary, device-independent metafile of plotting commands, which must be converted for use by a specific hardware device. At the simplest level, the low level plotting commands are a sequence of pen

up, pen move and pen down commands. Some of the early plotting devices supported were Calcomp mechanical plotters, Versatec electrostatic printers and Tektronix graphics terminals. Today graphics output is supported for X-Windows, and PostScript printers. Only a small subset of output devices are currently supported, primarily because of the existence of excellent conversion software; one example of which is *ghostscript* which converts PostScript to many devices. The ImageMagick and GraphicsMagick packages are very useful from converting Encapsulated PostScript to graphics bitmaps, such as PNG or JPEG, for inclusion into MS Word and PowerPoint documents.

If a CALPLOT device filter is named *plotdev*, one uses the program as follows:

plotdev [options] < PLOTFILE *for a screen device*

plotdev [options] < PLOTFILE > temp_file *(create temp file)*
print temp_file *(output to the actual printer)*

Some common options are

-Scaling_factor

Multiply all plot moves by the *scaling_factor (default 1.0)*

-R

Rotate the plot by 90°

-Ffont

Change the default font to number font. The default is Times Roman. A

-F7 will invoke Helvetica Bold on a PostScript printer

Other commands are specific to the hardware device.

Computer Programs in Seismology - sacpsd

B.2. PostScript Output

```
plotnps [options]
-V                               Program Version
-Sscalefac (default=1.0)       Plot magnifier
-Ppipe     (default stdout)    Pipe output to process pipe
-R         (default off)       Rotate plot 90 degrees
-N         (default off)       Turn off shading
-Ffont     (default 0)         Default font
                                0 Times-Roman
                                1 Times-Roman
                                2 Times-Italic
                                3 Times-Bold
                                4 Symbol (Greek)
                                5 Helvetica
                                6 Helvetica-Oblique
                                7 Helvetica-Bold
                                8 Symbol (Greek)
                                9 Courier
                                10 Courier-Oblique
                                11 Courier-Bold
                                12 Symbol (Greek)
-H30      (default H60)        Halftone for shading larger dots
-H60      (default H60)        Halftone for shading
-K        (default gray-)      Color PostScript output
-KW       (default gray-)      Color PostScript output, whitened spectrum
-KR       (default gray-)      Color output Red->White->Blue
-KB       (default gray-)      Color output Blue->White->Red
-G        (default gray-)      Gray PostScript output
                                (default is gray shading but all black colored lines)
-B        (default 8.5x11)     Paper is 11 x 14
-L        (default 8.5x11)     Paper is 8.5x14
-A3       (default 8.5x11)     Paper is A3
-A4       (default 8.5x11)     Paper is A4
-W        (default 0)          Line width in units of 0.001 in or 0.0025cm)
-EPS      EPS output
-Ttitle   (default off)       Title at bottom left of page
-X0xoff   (default 0)         x-offset in CALPLOT units
-Y0yoff   (default 0)         y-offset in CALPLOT units
-h        Do not execute, show options
-?        Do not execute, show options
```

Standards

To be compatible with PostScript display software and with word processing software that permits inclusion of PostScript files, PostScript Document Structure Convention 3.0 (DSC 3.0) is followed.

Plotspace Mapping

The CALPLOT definition of axes is such that the X-axis is horizontal and the Y-axis is vertical. This is then mapped onto a printed page of dimension 8.5" x 11". In the default case the X-axis is mapped onto the long dimension of the paper. The plot space on the paper is demonstrated in Figure 1.

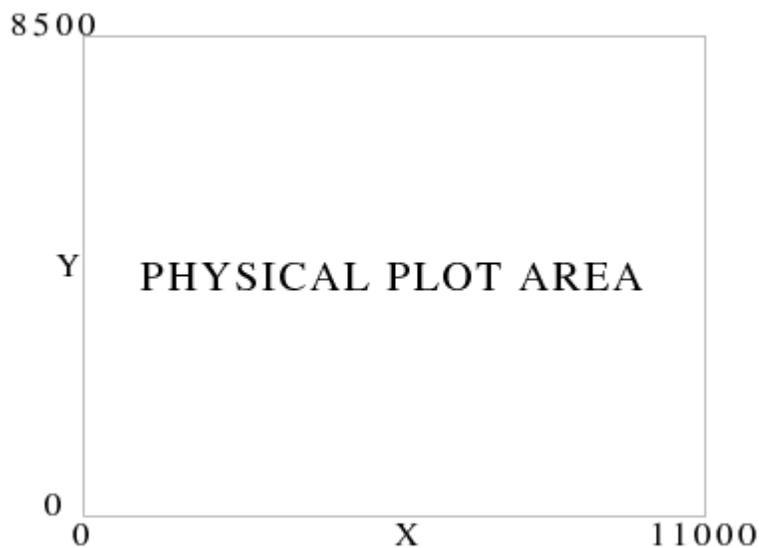


Fig. B.1. Default mapping of CALPLOT plot space onto physical page showing the CALPLOT units.

The -R option rotates the mapping, such that the Y-axis is mapped onto the long dimension of the paper. This plot space on the paper is shown in Figure 2.

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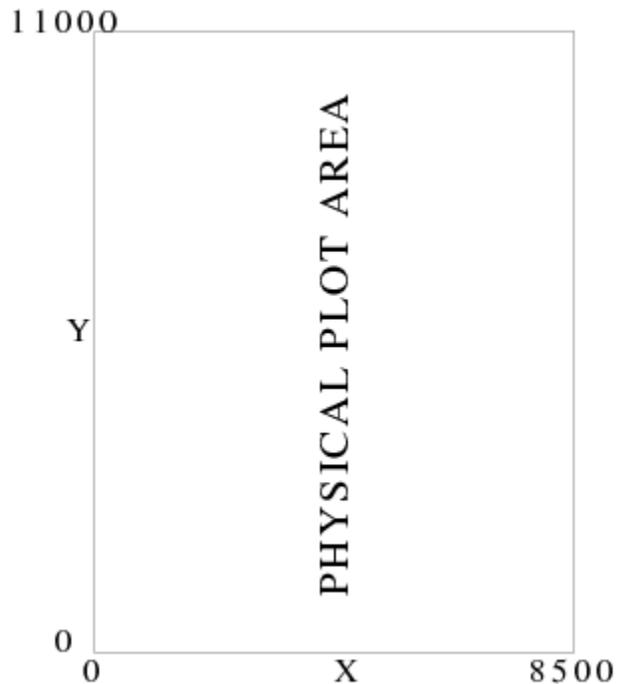


Fig. B.2. Mapping of CALPLOT plot space onto physical page using -R

Note that the CALPLOT plot space is mapped onto a rectangular page with no distortion of the unit lengths of the X- or Y-axes.

EPS EXAMPLES

The PostScript plot space is assumed to be that the X-axis is horizontal with a length of 8.5" and the Y-axis is vertical with a length of 11.0". The use of the **-EPS** or **-LEPS** options permits a plot to be able to fit within these limits. For the **-EPS** option, the CALPLOT X-axis will still be horizontal, which is required for inclusion in **groff** or **latex** documents. The default and **-R** option changes the lengths of the plotted axes in the manner consistent with Figures 1 and 2. The **-LEPS** option make the X-axis parallel to the long direction of the page.

The following examples use the second page of the graphics test file PLTTST to illustrate the result of using this program with different options.

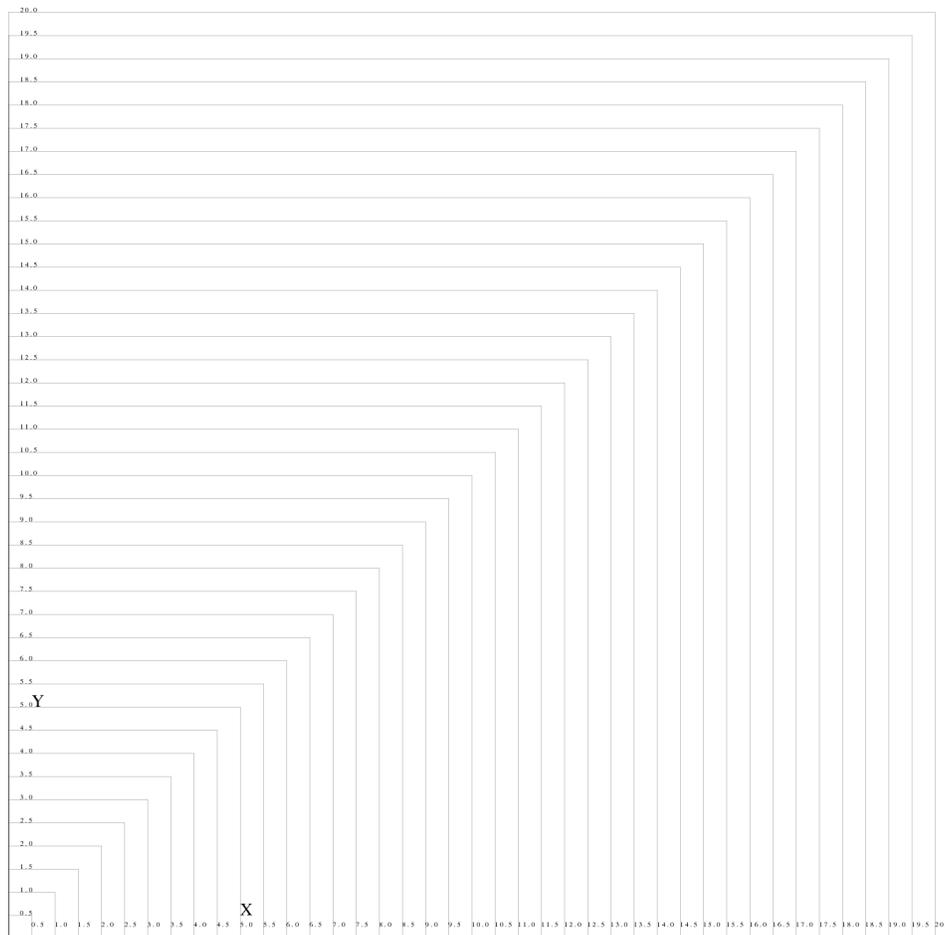


Fig. B.3. This is the result of using plotnps -EPS < plt > plttst.eps

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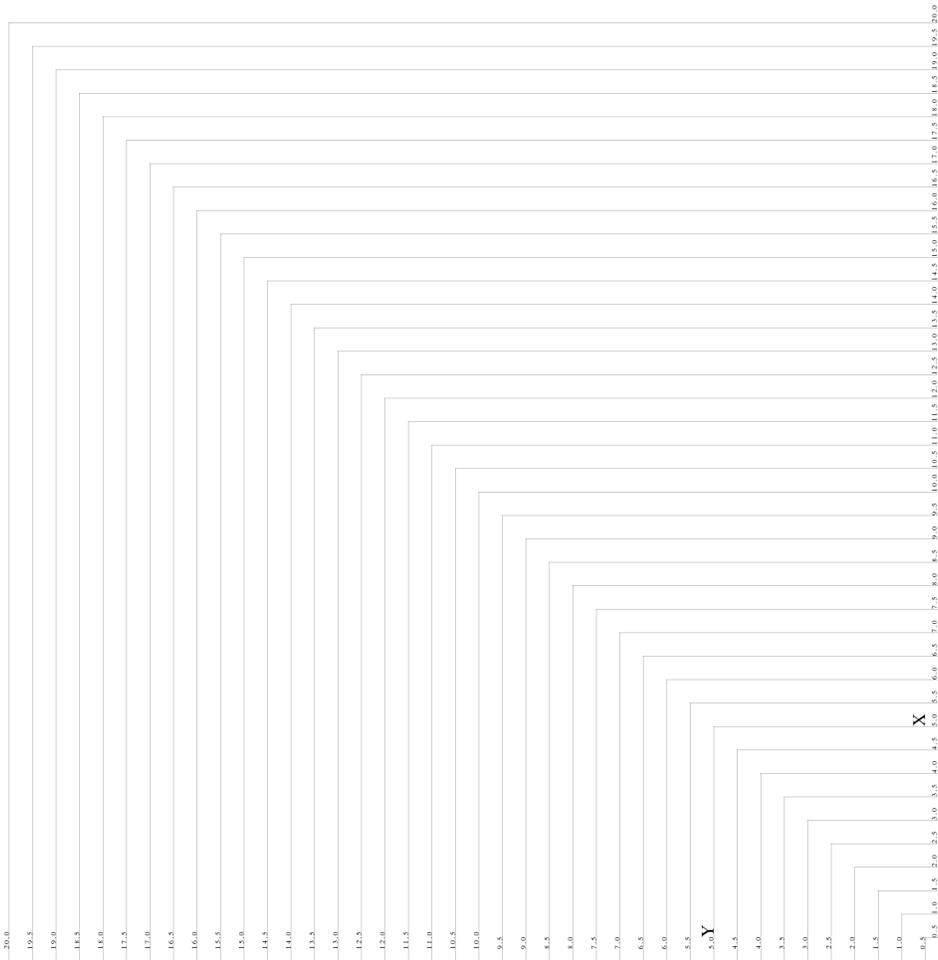


Fig. B.4. This is the result of using `plotnps -EPS -R < plt > plttst.rps`

B.3. X11 Output

The program `plotxvig` is a native X11 program for use under the X11 windowing system. It is based on the XviG Version 1.1 package (Antoon Demarrée, IMEC, ©1993). This program supports 35 unique colors in its palette. If these colors are not available, dithering is used to create the apparent set. This package is also the basis of interactive X11 software.

Program control is through the command line:

```
plotxvig [options]
      -V                      Program Version
```

```

-Sscalefac (default=1.0) Plot magnifier
-R         (default off) Rotate plot 90 degrees
N         (default off) Turn off shading
-I         (default off) Invert background (e.g., black)
-Ffont    (default 0)   Default font
                    0 Roman
                    1 Roman
                    2 Italic
                    3 Bold
                    4 Symbol (Greek)
-K         (default color) Color output Red->Green->Blue
-KR       (default -K  ) Color output Red->White->Blue
-KB       (default -K  ) Color output Blue->White->Red
-Kr       (default -K  ) Color output White -> Red->Blue->White
-Kb       (default -K  ) Color output White->Blue->Red->White
-G         (default -K  ) Gray output
-W         (default 0)   Line width in units of 0.001 in or 0.0025cm)
-geometry (default off) Parse X11 geometry string
-geometry WIDTHxHEIGHT{+-}XOFF{+-}YOFF
-p         Put up positioning grid every 1000 CALPLOT units, same as -p1
-p2 every 500, -p4 every 250, -p10 every 100
-X0xoff   (default 0)   x-offset in CALPLOT units
-Y0yoff   (default 0)   y-offset in CALPLOT units
-C         (default off) Implement crosshairs for the mouse cursor
-h         Do not execute, show options
-?         Do not execute, show options

```

To provide additional user control, the command line arguments can be placed in the environment by separating them by colons (:) with no intervening spaces. This is the only way to change display options when using the graphics libraries for interactive plots, such as in the programs **gsac**, **do_mft** or **do_pom**. To force a scale factor of 0.5, and the images size of 800x600 one would set the environment parameter PLOTXVIG

```

PLOTXVIG=-S0.5:-g:800x600:
export PLOTXVIG      (under sh or bash)

```

or

```

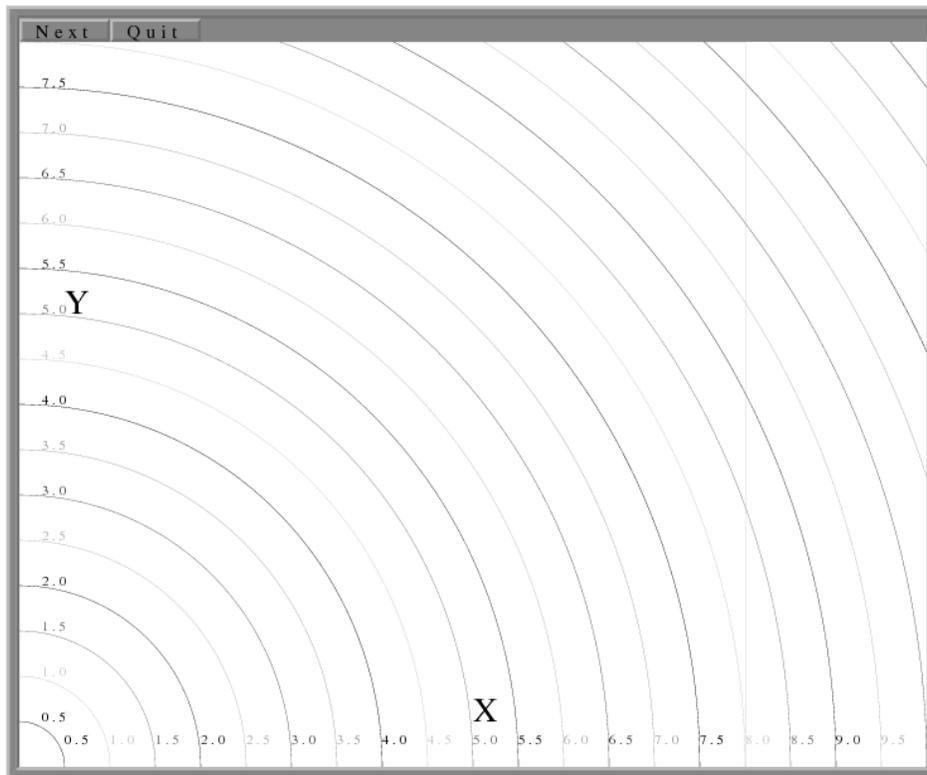
setenv PLOTXVIG=-S0.5:-g:800x600:  (under csh)

```

The X11 screen is viewed as a piece of paper exactly 10.0" wide and 8.0" high (approximately 25.4 cm wide by 20.32 cm high). The default screen has dimensions of 800 x 640 pixels, which can be changed

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through the window manager when the program begins. The following screen would appear:



When the page is completely drawn, a cursor will appear. One can use this to point to a feature of interest. The following actions can be performed:

- Pressing and releasing the Left Mouse Button will advance the page.
- Pressing the menu button Next will advance the page.
- Pressing the menu button Quit terminates the plot.

To be consistent with X11, the geometry of the plot window can be specified by an entry in the `.Xdefaults` file:

```
plotxvig.calxvig.plotxvig.geometry: 1000x800+100+50
```

In order of importance, an entry such as this overrides a command line or environment option. For the other options, the command line overrides the PLOTXVIG environment control.

Problems:

Resizing a window after plotting begins will truncate the plot, if the window is smaller, or will have unused areas. Because of the size of the binary plotfiles, there is no way to rewind and redraw a plot. Instead a backup image is used.

Finally **plotxvig** works by starting two UNIX processes: one do the drawing, the other to handle events and to place the drawing on the screen - an interesting use of interprocess communication. You may find yourself with a display that is not responsive - this usually happens because one, but not both processes have terminated. Use `ps` to list the processes, select the process ID number, PID, and then kill PID to get rid of **calxvig** and **plotxvig**.

B.4. Figure Manipulation

The program **reframe** permits manipulation of a CALPLOT figure, either by changing the position on the page or by imposing a primitive clipping. Options exist to select one figure of a multi-page plot file, and to merge plot files. The output of this program is another plot file. The program input is from the last argument on the command line, if that argument is not a command flag, or the standard input

Program control is through the command line:

```
reframe [flags], where the command flags are
-O
    Redirect the output to the standard output. Otherwise a plotXXXXXX
file    will be created, where XXXXX is a unique identification number.
-P
    Force the output to be a plot file. This the default.
-Mmergefile
    This is the file that will be superimposed onto the original file.
-XLx_low_clip
    (default = -100000000)
-XHx_high_clip
    (default = 100000000)
-YLy_low_clip
    (default = -100000000)
-YHy_high_clip
    (default = 100000000)
    A selected position of the input figure can be passed through to the
    output. The selected region is bounded by these coordinates.
-X0x_origin
-Y0y_origin
    These values are added to the (x,y) coordinates of all input values
    within the clipping window to shift the resulting figure on the page.
```

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The sequence of operations is that first the image is clipped, and then the origin is shifted.

To illustrate the usage of the program, consider the following two examples:

To merge the second frames of two plot files, one need only do

```
reframe -N2 -O -MPLOTrhwvint < PLOTrefplt > PLOTrefplt2
```

Note that the page number flag applies to both input files. It may be necessary to run the program three times to select the desired pages, first two runs, and then to merge the output using the temporary files.

To select the first three pages of a multi-page plotfile, and then to combine them on to a single page,

```
reframe -V -XH8500 -YH11000 -N1 -O < TABL > hunk1
  ( retrieve page 1 and save in the file hunk1)
reframe -V -XH8500 -YH11000 -X0+8750 -N2 -O < TABL > hunk2
  ( retrieve page 2, move plot 8750 units to right and
    save in the file hunk2)
reframe -V -XH8500 -YH11000 -X0+17500 -N3 -O < TABL > hunk3
  ( retrieve page 3, move plot 11000 units to right and
    save in the file hunk3)
reframe -V -N1 -O -Mhunk2 hunk1 > munk1
  ( merge the files hunk2 and hunk1 into the file munk1)
reframe -V -X0+1000 -Y0+1000 -N1 -O -Mhunk3 munk1 > PLOTreframe2
  ( merge files hunk3 and munk1, and shift the origin 1000 units to
    the right and upward)
```

The CALPLOT programs are used, 1000 units correspond to 1.000 inches on the hardcopy plot.

The results of another example are shown in Figures A.5 and A.6. The object is to cut Figure A.5 into four quadrants centered at (4.0,4.0) and to exchange the upper right with the lower left quadrant and the upper left with the lower right quadrant. The commands used are as follow:

```
reframe -N1 -O < PLTTST > p
reframe -N1 -O -X0+4000 -Y0+4000 -XL0000 -XH4000 -YL0000 -YH4000 < p1 > g1
reframe -N1 -O -X0-4000 -Y0+4000 -XL4000 -XH8000 -YL0000 -YH4000 < p1 > g2
reframe -N1 -O -X0+4000 -Y0-4000 -XL0000 -XH4000 -YL4000 -YH8000 < p1 > g3
reframe -N1 -O -X0-4000 -Y0-4000 -XL4000 -XH8000 -YL4000 -YH8000 < p1 > g4
reframe -N1 -O -Mg1 < g2 > g5
reframe -N1 -O -Mg3 < g4 > g6
reframe -N1 -O -Mg5 -X0+1000 -Y0+1000 < g6 > g7
plotnps -F7 -W10 -G -EPS < g7 > g7.eps
```

```
rm p1 g1 g2 g3 g4 g5 g6 g7
```

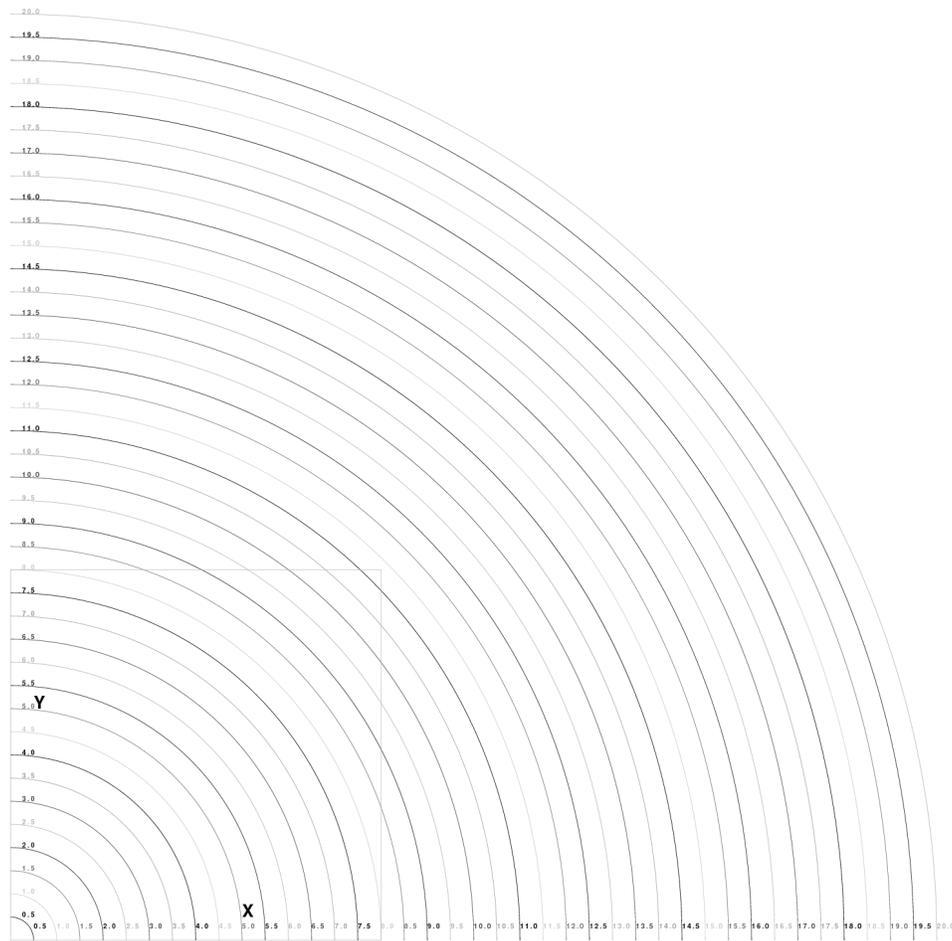


Fig. A.5 . Initial plot to be sectioned

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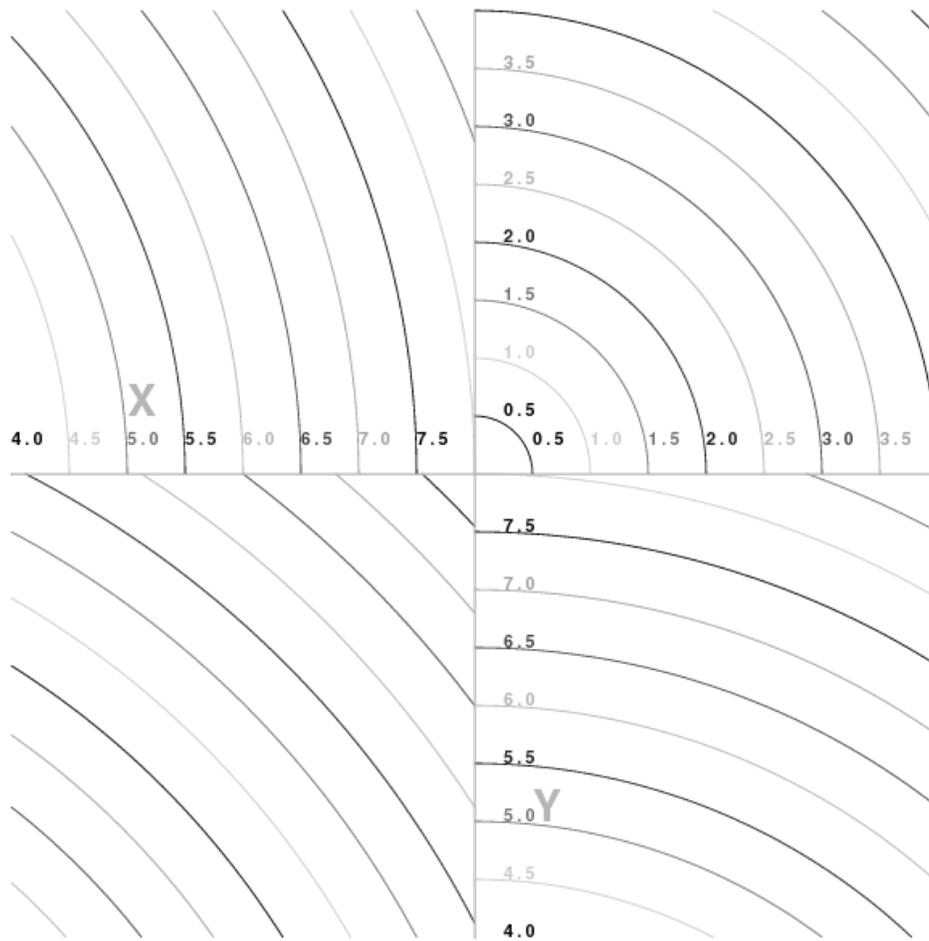


Fig. A.6. Result of clipping and shifting

B.5. CALPLOT Colors

Many programs permit the user definition of colors for curves. These are invoked using

-Kflag

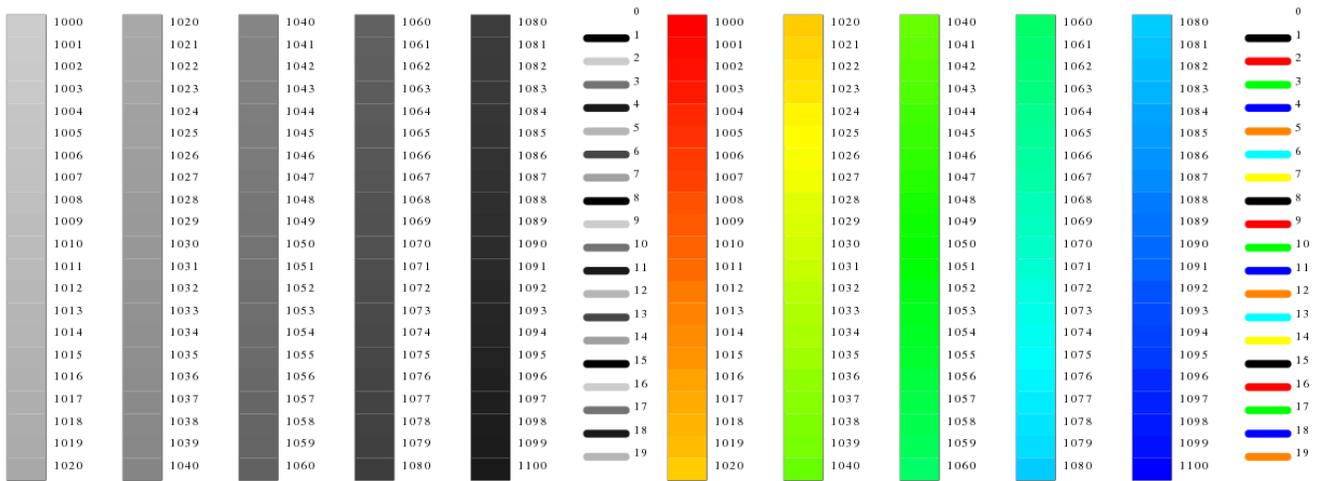
The CALPLOT graphics uses a set of predefined colors that take on slightly different meanings

depending upon whether the plot program (plotxvig, plotnps, and plotgif), is invoked with the -G, -K, -KR or -KB flags. Values of *kolor* between 0 and 999 are repeated as a specified sequence of 7 colors. Values in the range 1000 - 1100 select a palette of continuous color tones selected by the use of these flags. The table below defines some of these values as do the figures, which are best viewed on a color terminal screen using GhostView or Acroread.

Kolor	-G	-K	-KR	-KB
0	Background	Background	Background	Background
1	Foreground	Foreground	Foreground	Foreground
2	(see below)	Red	(see below)	(see below)
3		Green		
4		Blue		
5		Orange		
6		Blue-Green		
7		Yellow		
8	Foreground	Foreground	Foreground	Foreground
9		Red		
999				
1000	Lt. Gray	Red	Red	Blue
1025		Orange	Lt. Red	Lt. Blue
1050	Med. Gray	Green	White	White
1075		Blue-Green	Lt. Blue	Lt. Red
1100	Dark Gray	Blue	Blue	Red

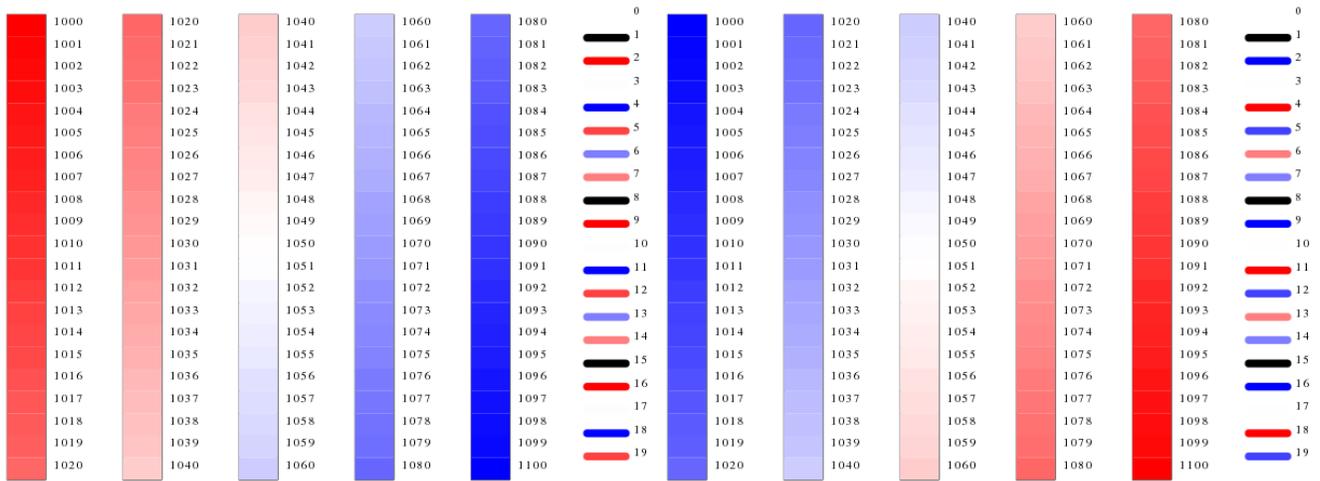
Normal plotting uses the -G and -K flags. Displays of continuous color maps can use the -KR and -KB modes if the color indices are programmed to represent a range of negative - positive values with white representing a median value. The following figures show the resulting colors for a given choice of the *kolor* index.

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plotnps -G < GRAYSC

plotnps -K < GRAYSC



plotnps -KR < GRAYSC

plotnps -KB < GRAYSC