Strainmeter Metadata

Strainmeter metadata includes general information about the instrument, information about each data channel and historical information about the site such as the date and time the site was visited. All information regarding the PBO strainmeters is recorded in the PBO Operational Database. A subset of this information is extracted from the POD and sent to the archives at IRIS DMC and NCEDC in SEED format.

PBO will send the archives miniSEED files of time series data only and dataless SEED files that contain metadata for each strainmeter. The archives will combine the dataless SEED and the miniSEED files into a SEED file when a user requests data. PBO will make every effort to keep the dataless SEED files up to date. PBO engineers have a 48-hour time limit within which to alert the Data Management Team in Boulder of any changes at the instrument site. PBO will then generate a new dataless SEED file and send it to the archives as soon as they get the field information.

When you download a SEED file the rdseed program will print out the metadata associated with each channel in a SEED volume. For example

rdseed –s –f SFGAR.RV0.CrescentCity2005

will produce an ASCII output of instrument metadata associated with each channel in that SEED volume.

An alternative way to examine the metadata associated with every data channel recorded at a strainmeter site is to use the IRIS software PDCC (http://www.iris.edu/manuals/) to examine the dataless SEED file for each station. PDCC provides a GUI interface that allows you to examine the contents of a dataless SEED file. We shall use PDCC to look at a dataless SEED file for a laser strainmeter and a Gladwin tensor strainmeter. Dataless SEED file can be downloaded at http://ftp.iris.washington.edu/pub/RESPONSES/DATALESS_SEEDS/ .

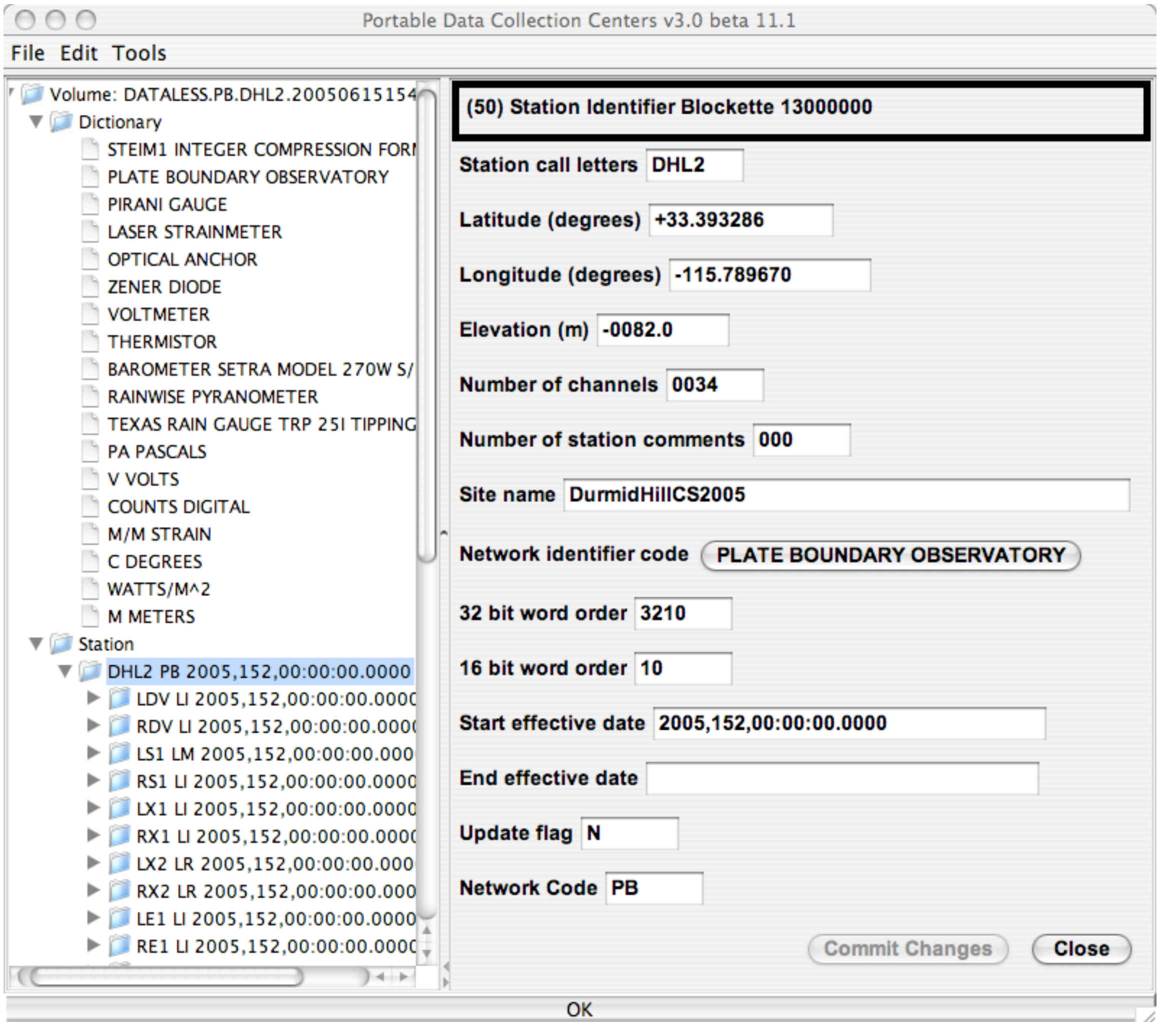


Figure 1. Station Information (Blockette 50) for Durmid Hill Laser strainmeter.

Laser strainmeter dataless SEED: Durmid Hill.

Information is recorded in units of metadata called blockettes. The dataless SEED file contains a dictionary component that describes all the terms used in the dataless SEED file, a station identifier blockette and then information on each channel recorded at the station. A dataless SEED file can contain information on more than one station but the examples we are looking at just have one. Figure 1 shows the general station information associated with the Durmid Hill laser strainmeter. The station identifier blockette includes general information such as coordinates, start date and depth. The station call letters are the PBO 4-character identifier for the site, DHL2, and the site name is the 16-character name for the strainmeter, DurmidHillCS2005. Thirty-four channels of data are recorded at DHL2.

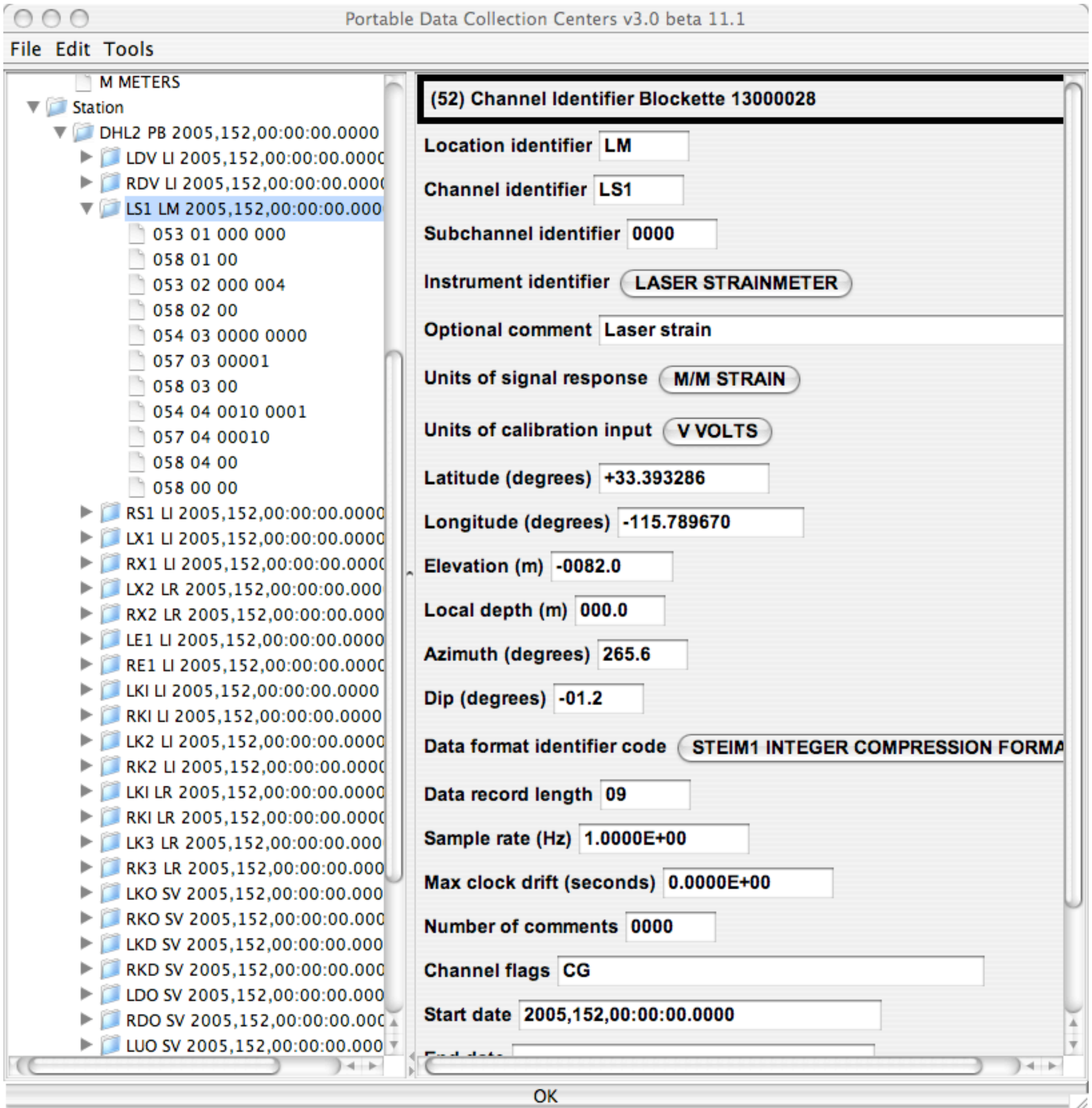
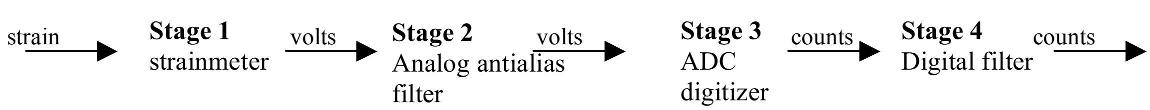


Figure 2. Channel identifier record for the strain channel measured by the laser strainmeter at DHL2.

There is a channel identifier blockette for each channel recorded (figure 2). Each channel is uniquely identified by its SEED codes. The example in figure 2 shows the strain measurement from DHL2. The SEED channel identifier is LS1, which represents the strain at the mid-point of the instrument. The SEED location code is LM. The coordinates and depths of the sensor plus information about the sample rate, clock tolerance and the units of input and output are also shown in this blockette.

The process of converting the measured signal from an analogue measurement to a digital signal is described in terms of stages and each stage is represented by separate blockettes of information. The 1 sample per second data is converted from the analogue to digital signal in 4 stages.



The 300 s interval data have an additional stage of decimation to reach a sample rate of 1/300 Hz. The dataless SEED file contains the information for each stage in the process of converting the strain to counts.

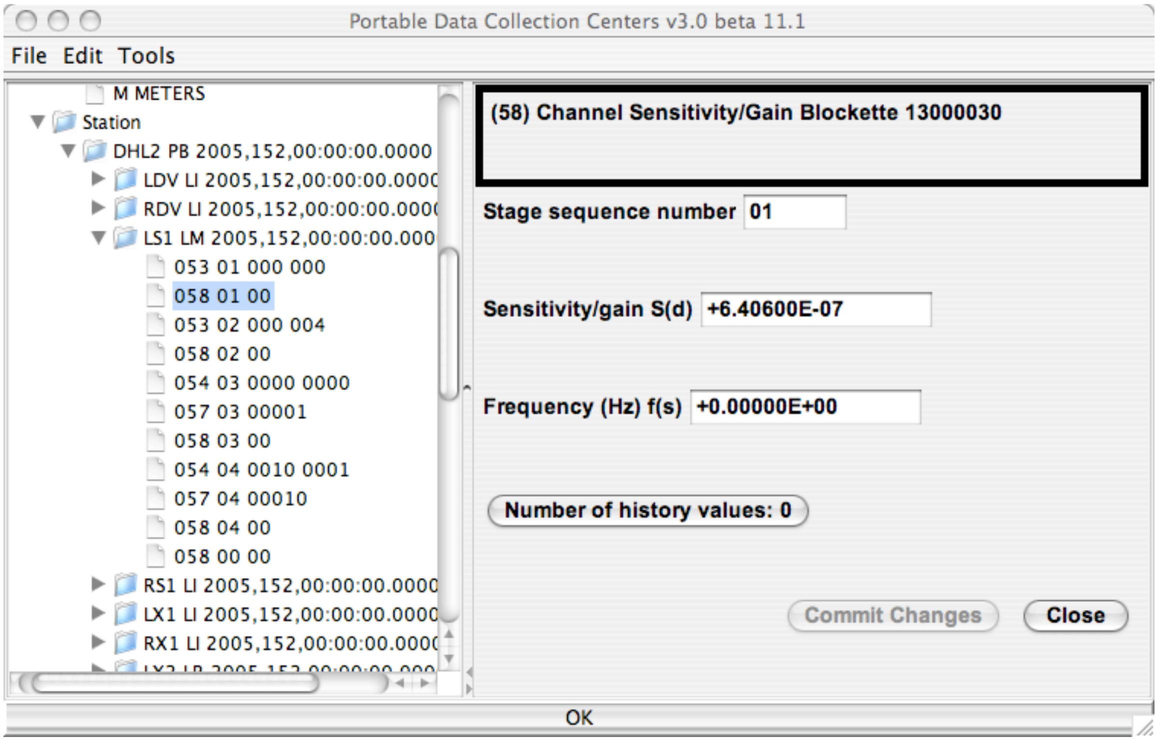


Figure 3. Stage 1 gain for the strain measurement at DHL2.

The first stage, the conversion of strain to volts, is described by blockettes 53 and 58. Blockette 53 indicates that in the first stage we convert strain to volts. Blockette 58 (figure 3) contains the scale factor at this stage. This scale factor represents the amount of strain per volt. In this example one volt is equivalent to 6.406E-7 units of strain. Since the response of the laser strainmeter is flat across all frequencies the frequency field is set to zero.

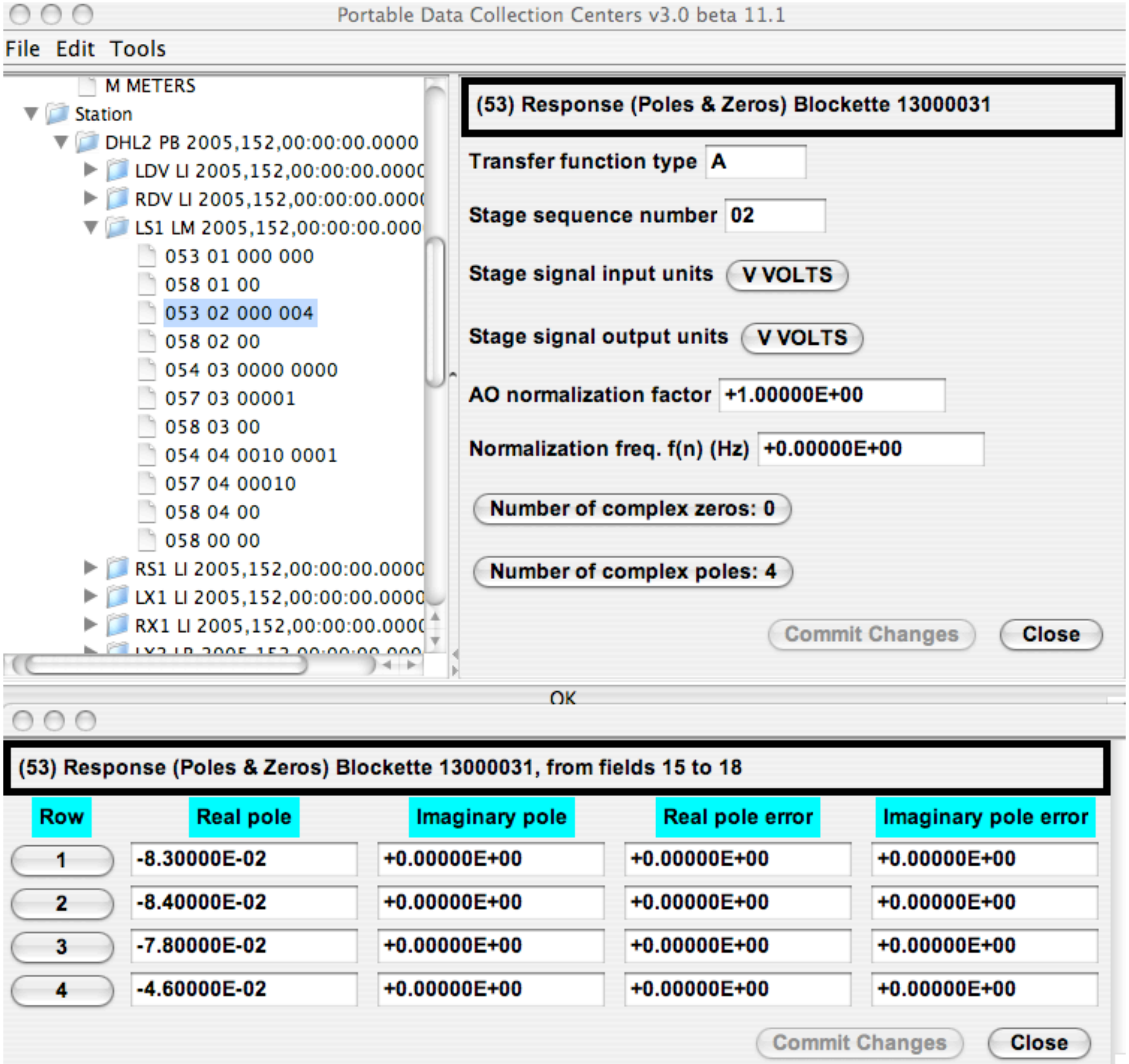


Figure 4. Stage 2, anti-alias filter.

Stage 2 describes the analog anti-alias filter that is applied to the data. The transform function is described in terms of poles and zeros. For this strain measurement there are 4 analog filters in series each one being a single-pole low pass filter (figure 4). Because the normalization factor is one the time constants for each filter can be collected together and shown as one filter. The gain at stage 2 is one.

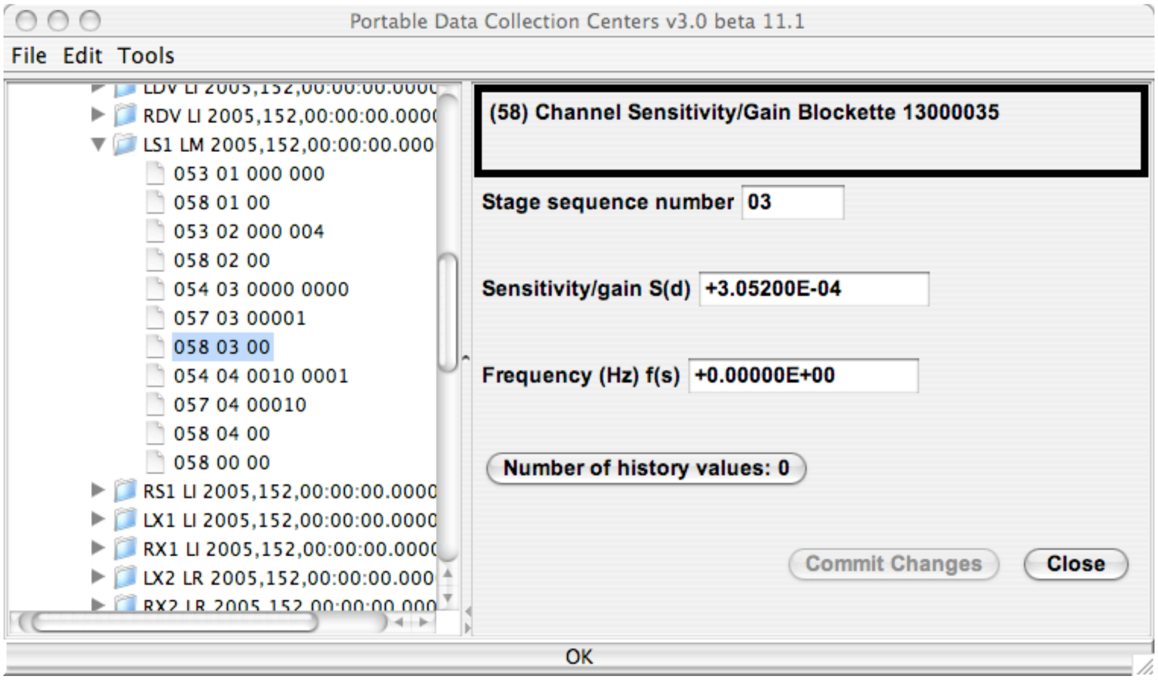


Figure 5.Blockette 58, channel sensitivity, stage 3.

Stage 3 describes the digitizing stage. The conversion from volts to a digital signal is described by blockettes 54, 57 and 58 that together describe a FIR filter. Blockette 54 contains the response information at this stage. Since we are not reducing the sample rate at this stage the number of numerators and denominators is zero. Blockette 57 describes the decimation applied, and the input and output sample rate. The decimation factor is one and the input sample rate (10 Hz) equals the output sample rate. There is no estimated delay or correction. Blockette 58 in stage 2 (figure 5) contains the number of volts per count. If the datalogger operates using 16 bits over a voltage range of ±10 Volts then the gain in stage 3 blockette 58 is $20/2^{16}$ = 0.3052E-3 volts per count.

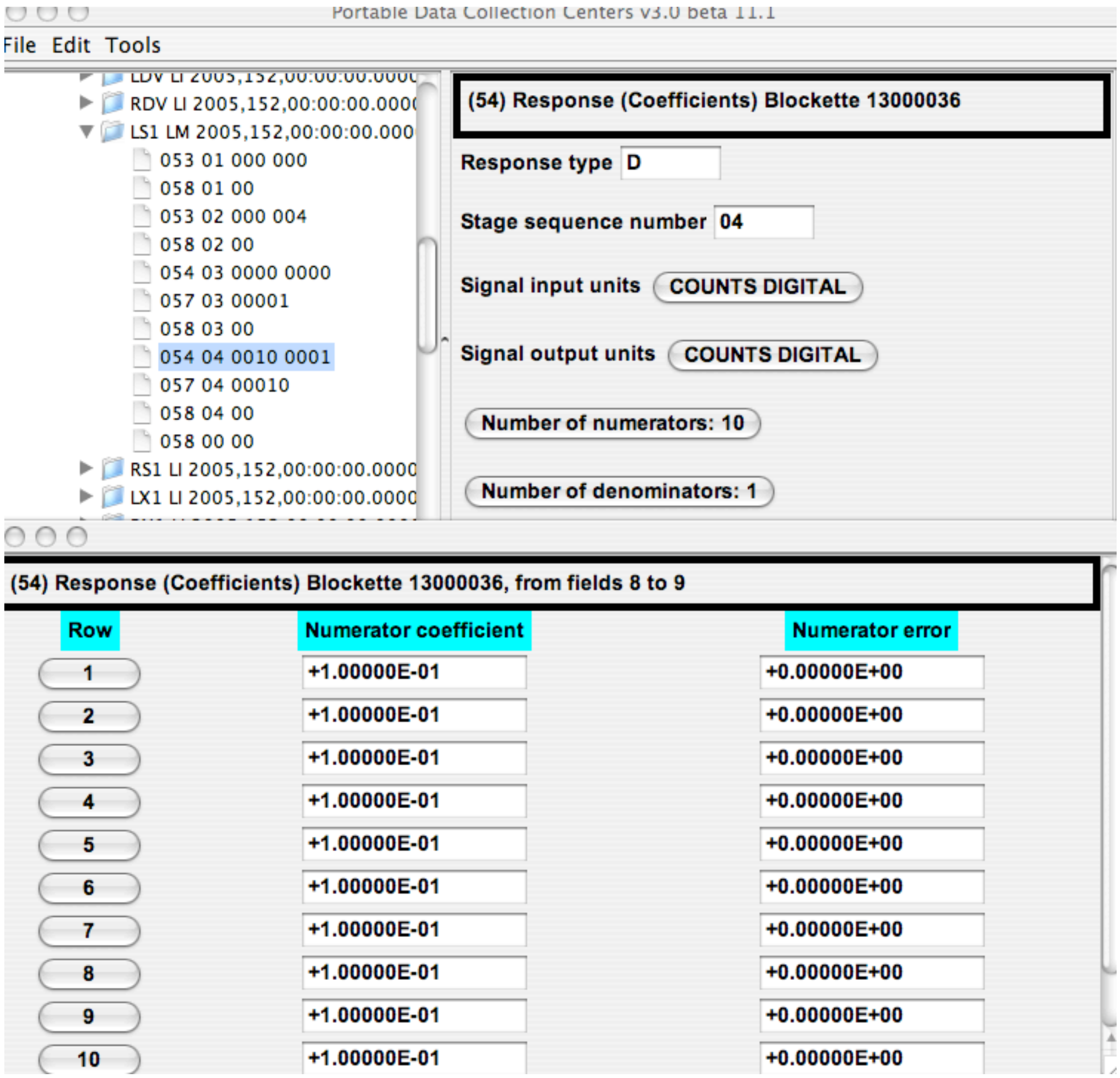


Figure 6. Stage 4 filter coefficients.

Stage 4 describes the reduction in sample rate from 10 Hz to 1 Hz. This is a digital stage where counts are input to the decimation filter and counts are output from it. Blockettes 54, 57 and 58 are again used to describe how the digital 10 Hz signal is down sampled to 1 Hz. The coefficients of the filter used to reduce the data are listed as numerators and denominators (figure 6). The strain measurements are digitized at 10 samples per second. The 10 samples are averaged to create a one-second data point and then the averaged data are decimated by a factor of 10. The result is a non-overlapping 10-point running mean.

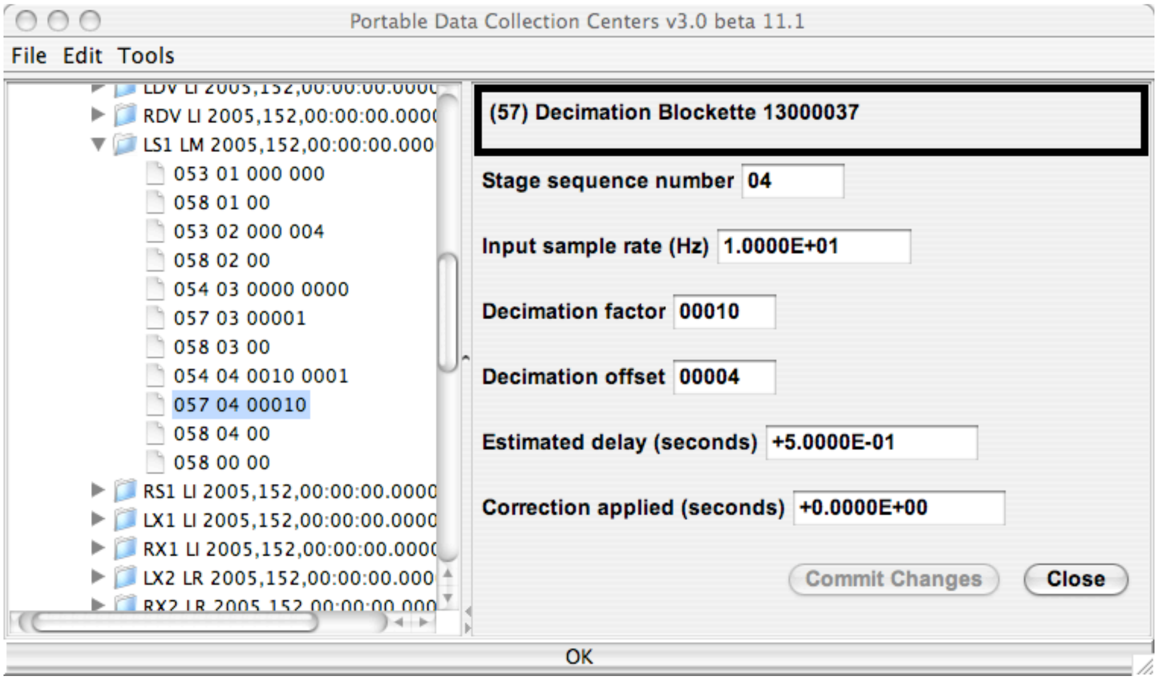


Figure 7. Decimation Blockette

The effect of the filter on timing is described in Blockette 57 (figure 7). The estimated time delay refers to the 5th data sample within each 10-point window. In this example no time correction is applied after the data are down sampled to 1 Hz. The sensitivity at this stage, described in blockette 58, is one.

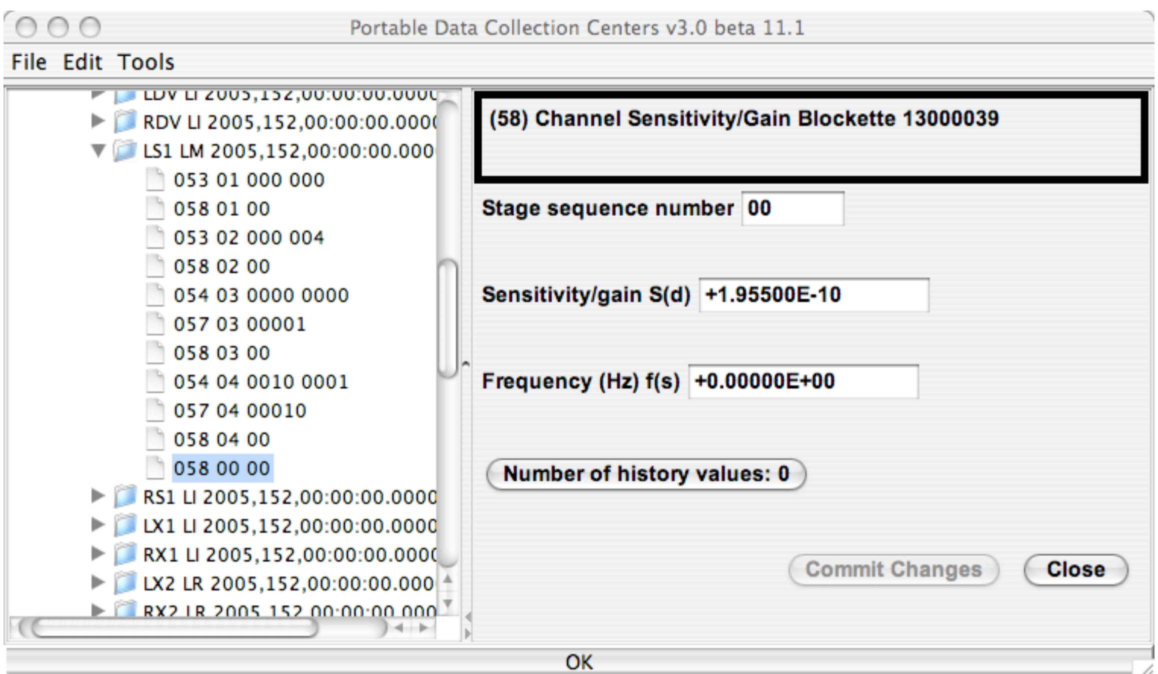


Figure 8. Channel Sensitivity.

The final blockette of the 1 sps strain data is the overall sensitivity blockette (Figure 8). The sensitivity in this blockette is the overall channel sensitivity, i.e., the amount of strain per unit count. It is equal to the product of the gains at each of the four stages. This value is the scale factor that should be used to convert the SEED data, which is in counts, to units of strain.

Borehole strainmeter dataless SEED: Hoko Falls.

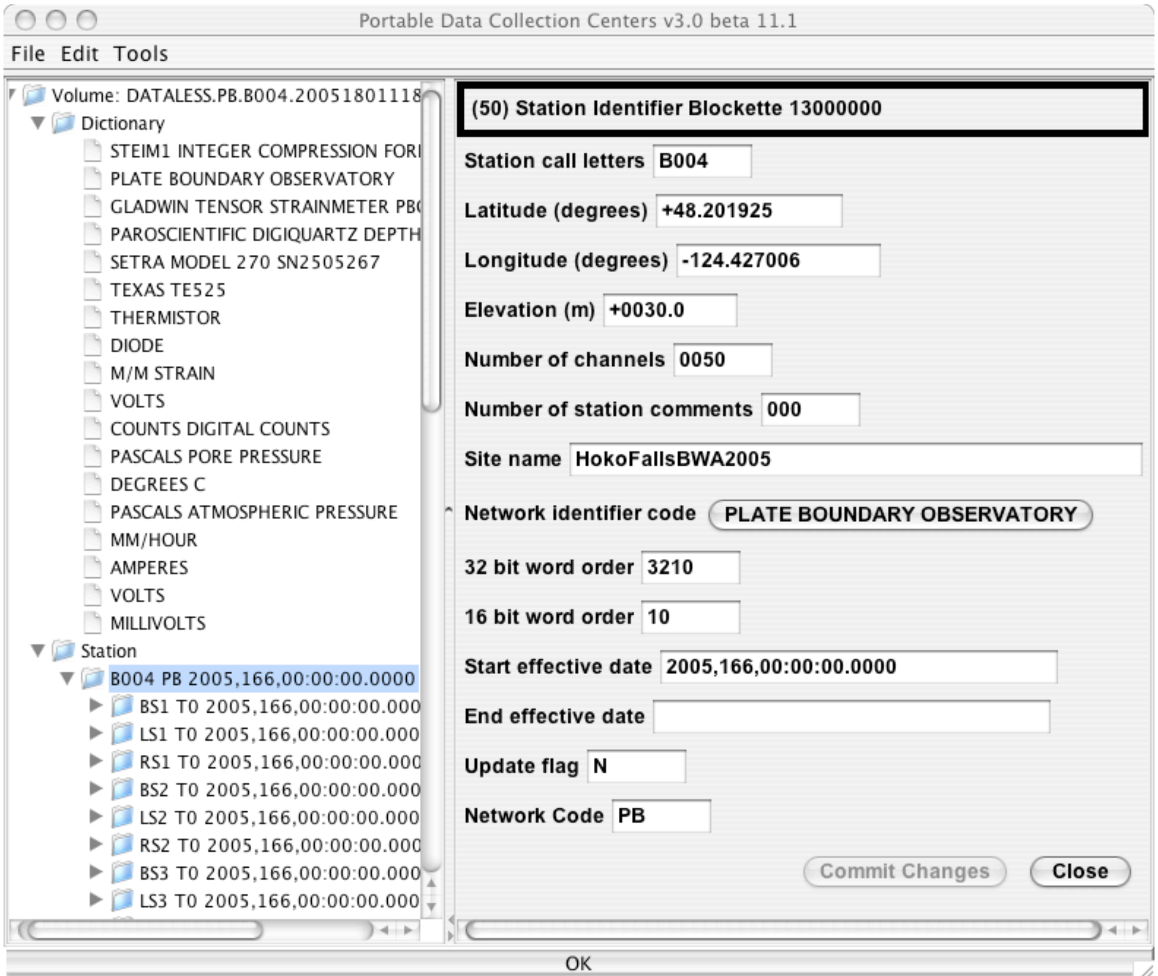


Figure 9. Station identifier blockette for B004.

The Gladwin Tensor Strainmeters record 50 channels of data including diagnostics, environmental and strain data streams. Figure 9 shows the station identifier blockette for the instrument installed at Hoko Falls in the Pacific North West. The station call letters are the PBO 4 character identifier, B004, and the site name is the PBO 16 character name, HokoFallsBWA2005. These are the names the instrument will be referred to in the PBO Operational Database.

As for the laser strainmeter, the responses for each data channel are described in a series of stages. Each stage contains blockettes of information. The GTSM is considered a two stage digital instrument.

strain → **Stage 1** strainmeter → counts → **Stage 2** digital filter → counts

The strainmeter measures strain and this is converted directly to counts in the first stage.

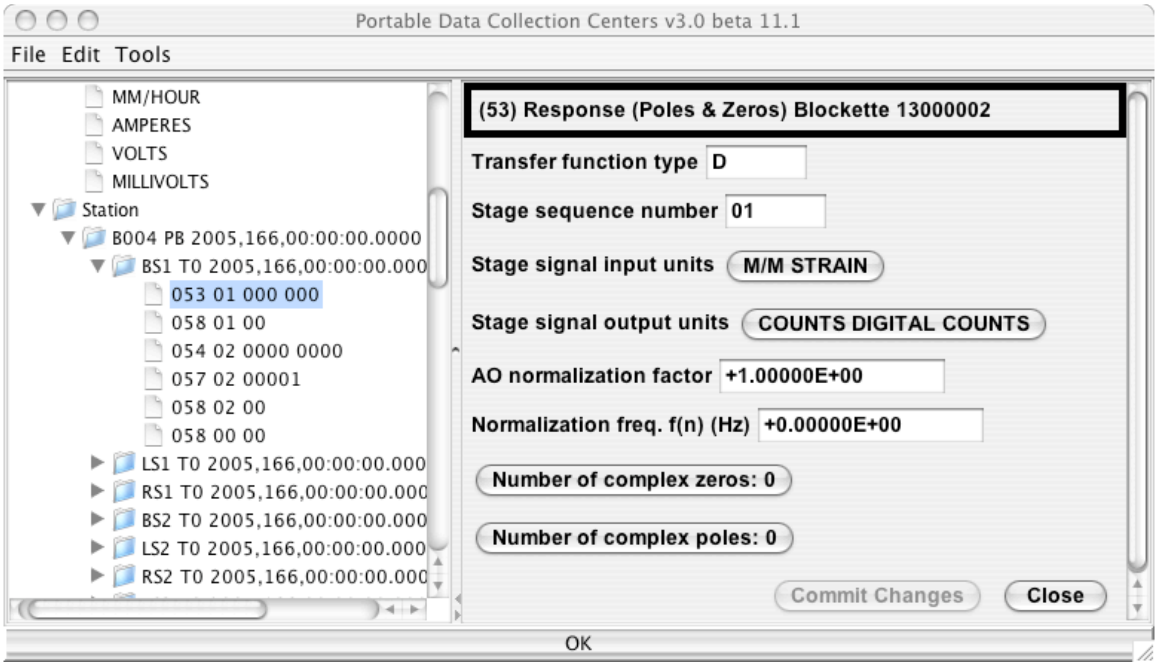


Figure 10. Stage 1 Blockette 53.

Figures 10 through 12 show the metadata for the 20 Hz stain data from gage of the Hoko Falls instrument. Blockette 53 of stage 1 (figure 10) records that the conversion from strain to counts is a digital one. The normalization frequency is zero and the normalization factor is set to 1.

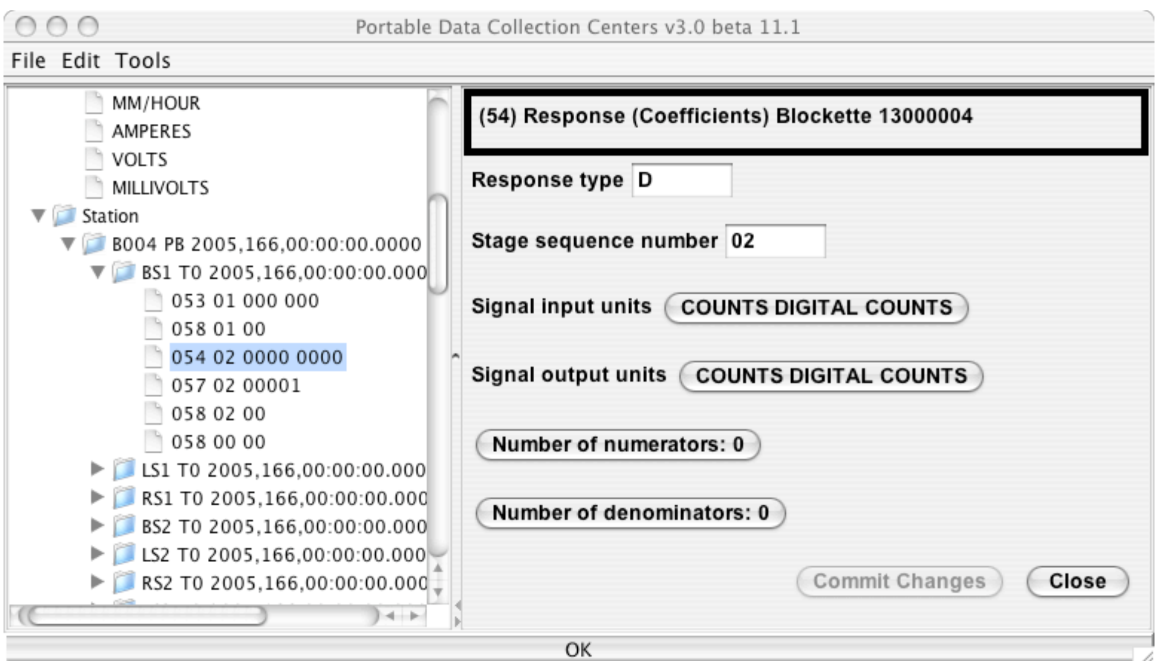


Figure 11. Stage 1. Blockette 54.

The GTSMs are engineered so that 1 count is equivalent to 0.1 nanostrain. The gain in stage 1, blockette 58 is therefore 1.0E-10 units of strain per count (figure 11).

Stage 2 represents the digital stage of the process and is recorded in stage 2 blockettes 54, 57 and 58. For these instruments the input sample rate is equal to the output sample rate. At this point there is no filtering or decimation information for the GTSMs though that metadata may be available in the future.

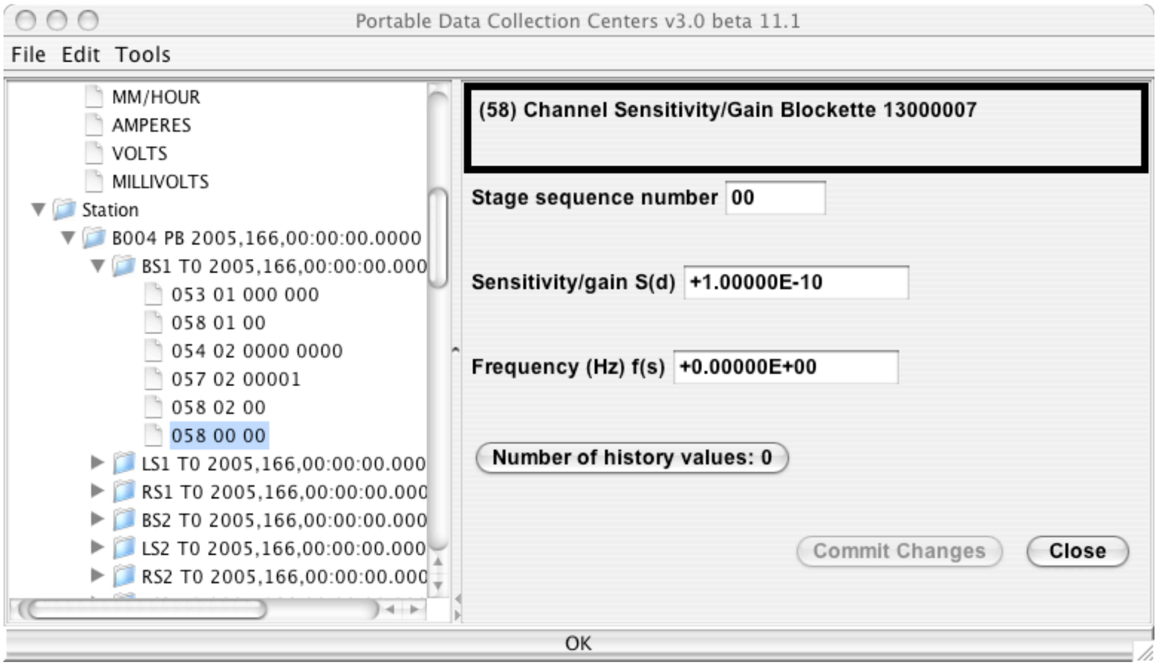


Figure 12. Overall channel sensitivity for the 20 Hz data from gage 1 at B004.

The final blockette 58 (figure 12) contains the overall channel sensitivity, i.e., what the user should multiply the SEED data by to get strain data. For all GTSM channels this is 1 count equals 0.1 nanostrain.