Computing seismic QC attributes, fold and offset sampling in RadExPro software

In this manual we will show how to compute the seismic QC attributes (amplitude and frequency characteristics, signal/noise ratio) as well as the fold and offset sampling (the latter being understood as the number of non-empty offset bins in each individual CDP bin) in RadExPro software.

If you want to recreate all the steps described in this document on your own, you should download the AttributesAndFoldDemo project. The project was specially designed to demonstrate only those steps that we need:

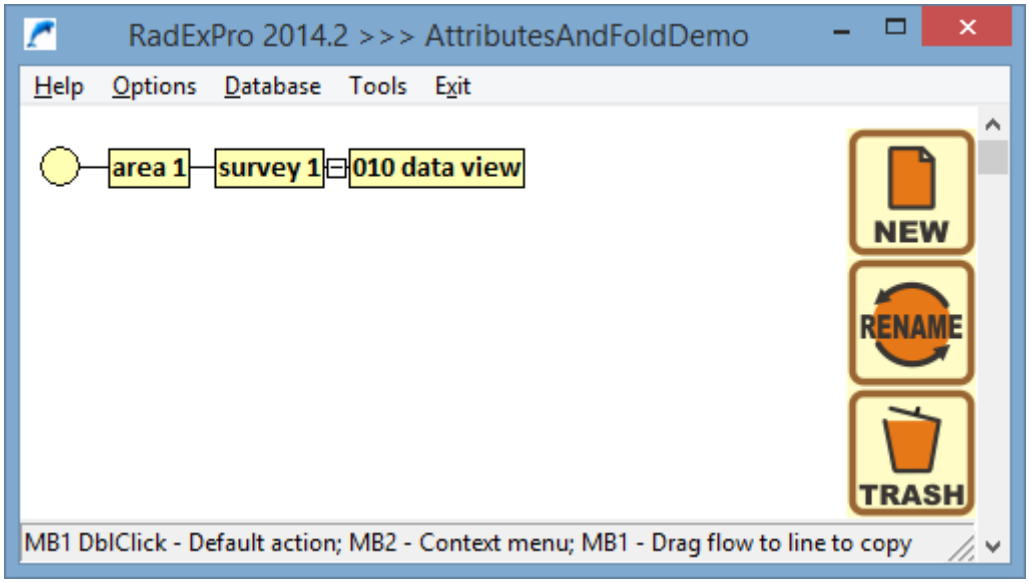
- Several auxiliary header fields which are absent by default were added to the project using the **Database/Edit header fields…** menu command: OFF_SMPL, AMP, AMP_N, FREQ, SNR and Q.
- A 3D onshore seismi survey data fragment was loaded into the project and had geometry assigned to it;
- The data were binned by CDP using the **3D CDP Binning** tool;

Only a small fragment consisting of just 20 shots was used in order to save space. However, we will be treating it as if it was an actual full-scale survey: the processing flows will be run in the *framed mode*, and instead of resorting the data in the **Trace Input** module at the flow input stage, we will use the specialized **Resort** module optimized for large data volumes (which is really unnecessary for such a small amount of data).

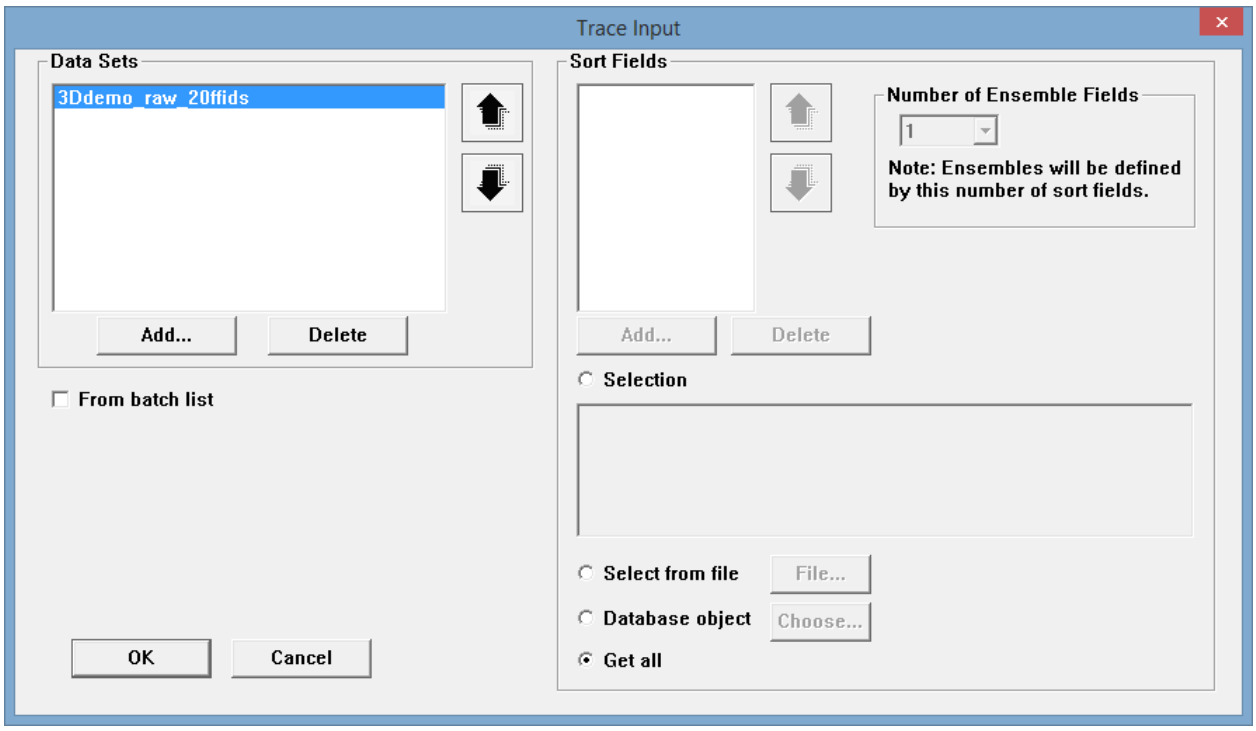
The computed attributes and fold values will be saved to the trace headers. The next step – mapping – is covered in the tutorial on Working with crossplots in RadExPro – seismic survey map, fold and offset sampling maps, and signal-to-noise ratio map.

Viewing the source data

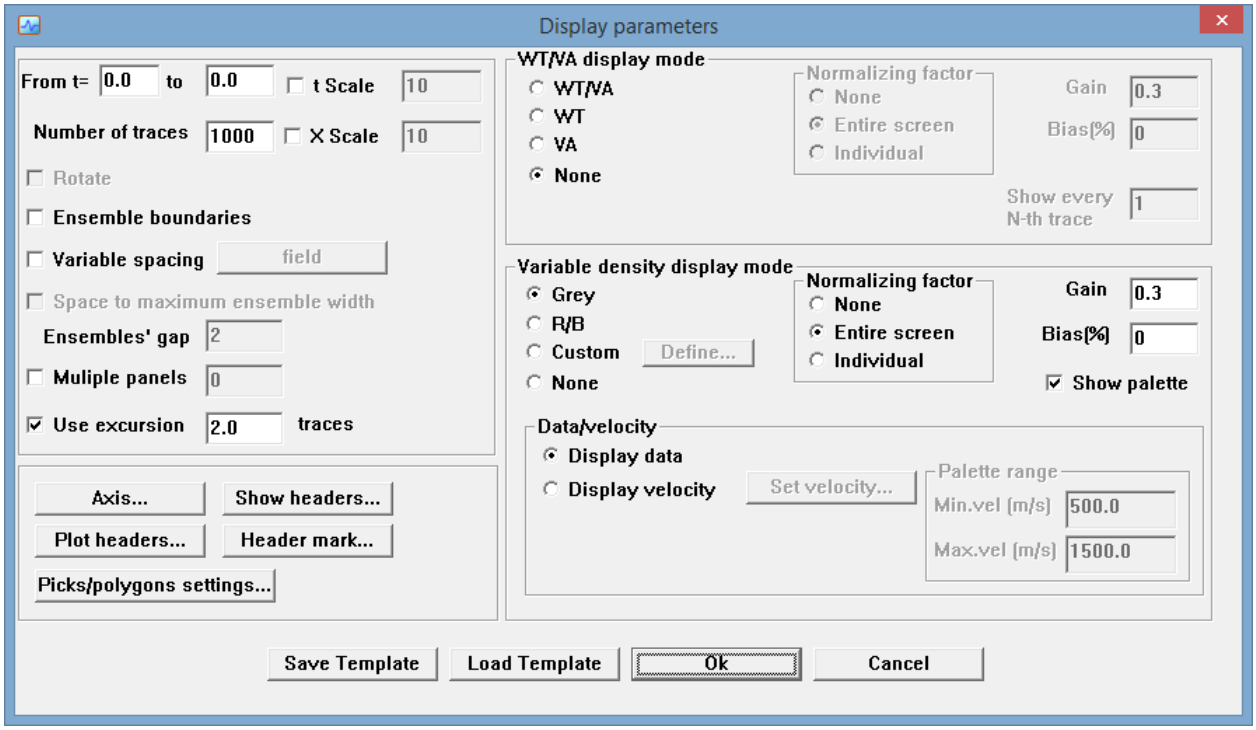
Open the AttributesAndFoldDemo project. The main project window should look like this:



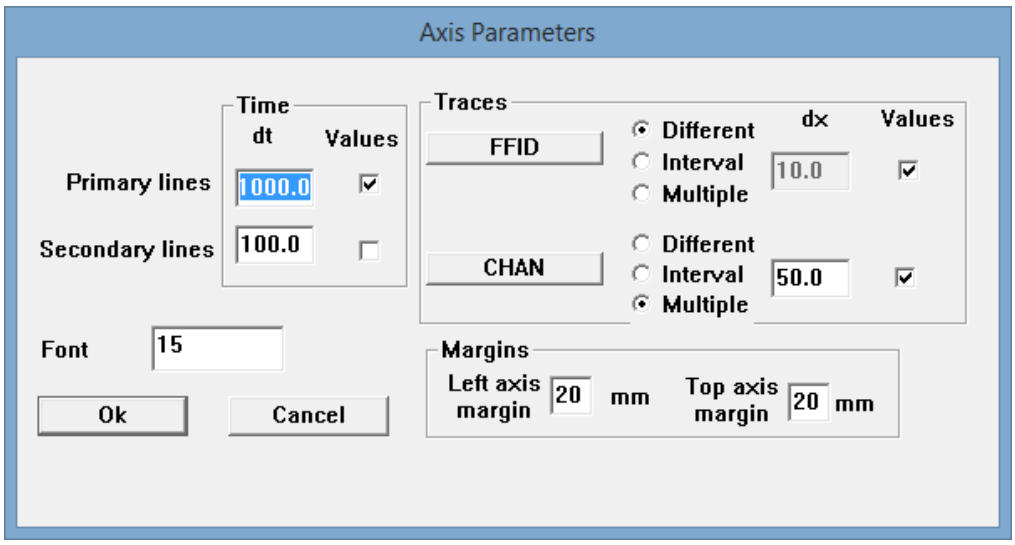
Open the already created **010 data view** flow. Add the Trace Input module to the flow, and select the 3Ddemo_raw_200ffids input data set (it is located on the **survey 1** level). Select the **Get all** options to load the data in the order in which they are stored without resorting:



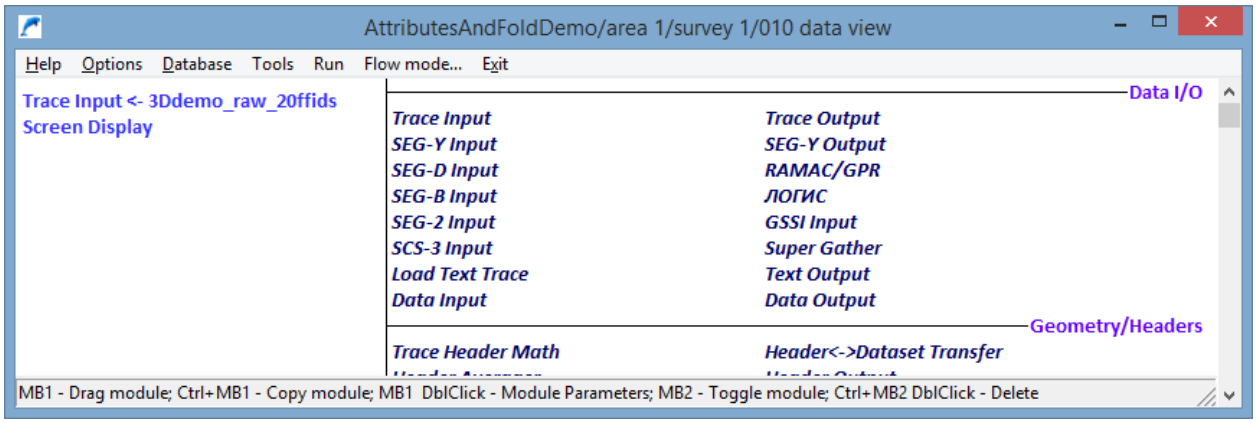
Press **OK** and add the Screen Display module to the flow. Select the **Grey** display mode and set the **Number of traces** per screen to 1000:



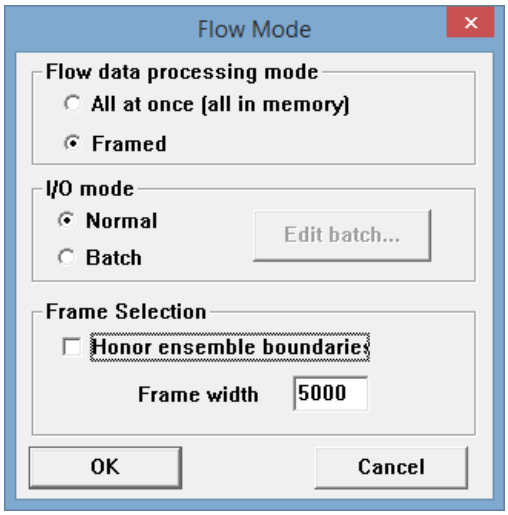
Press the **Axis…** button and set up the horizontal axis labels. We want to display the shot (FFID) numbers every time their value changes as well as the number of each channel which is a multiple of 50:



The flow should look like this:



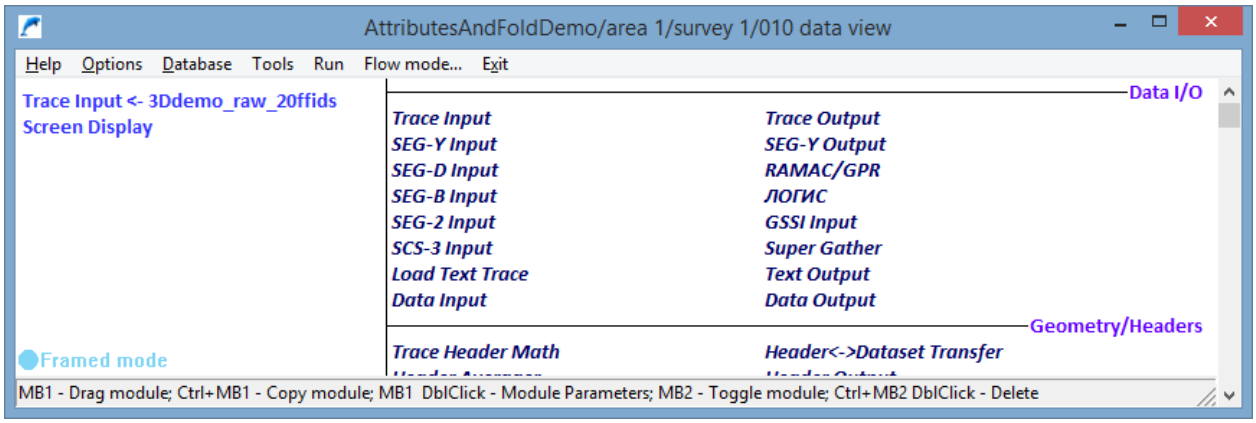
We could already run it as it is, but we should treat it as if we were dealing with a large 3D survey which exceeds the computer's RAM capacity – that is, enable the framed flow mode. To do this, select the **Flow mode…** menu command and set the **Framed** flow mode in the dialog box. You can set the **Frame width** to, for example, 5000 traces.



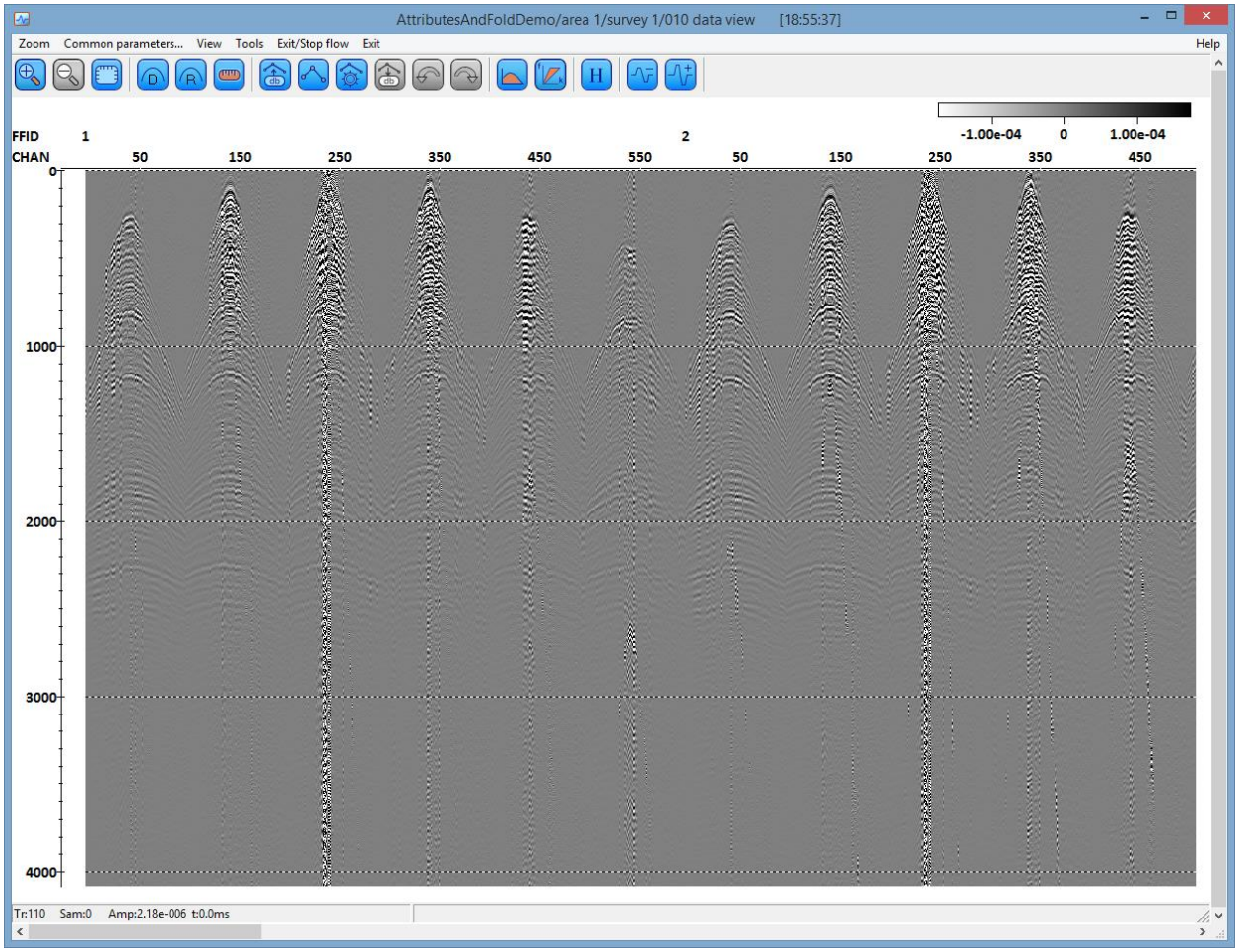
Important: Do not forget to uncheck the **Honor ensemble boundaries** box. In RadExPro, the ensembles are created by the Trace Input module, and an ensemble is considered to include all traces with matching values of the headers selected as the first N Sort Fields (N is specified in the **Number of**

Ensemble Fields field). Since we skipped sorting in our example (by enabling the **Get all** option), the software doesn't know where the ensemble boundaries are, and an attempt to honor the ensemble boundaries will lead to the program trying to read all the data into the RAM (and in case of an actually large survey, this will eventually result in an error since the program will run out of memory).

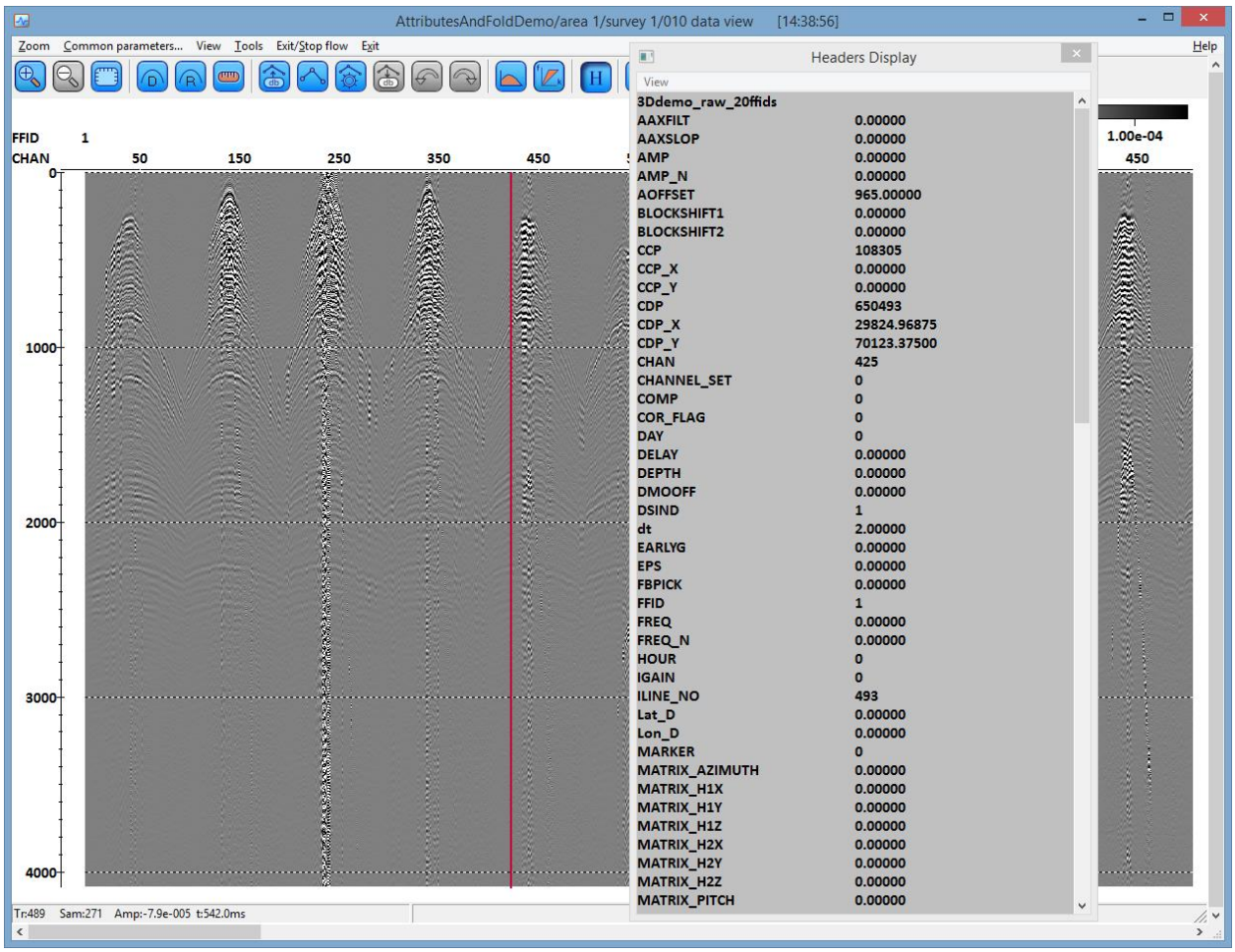
After setting the framed flow mode, a blue framed mode indicator will appear in the lower left corner of the flow editor window:



Now you can run the flow by pressing **Run** in the editor menu. The data for the first frame (5000 traces) will be shown in the **Screen Display** window.



You can see that the data are displayed in the same order as they are stored on the disk, and are sorted by FFID: CHAN (shot: channel). Press the  button on the toolbar and then click on any trace to view the headers associated with it:



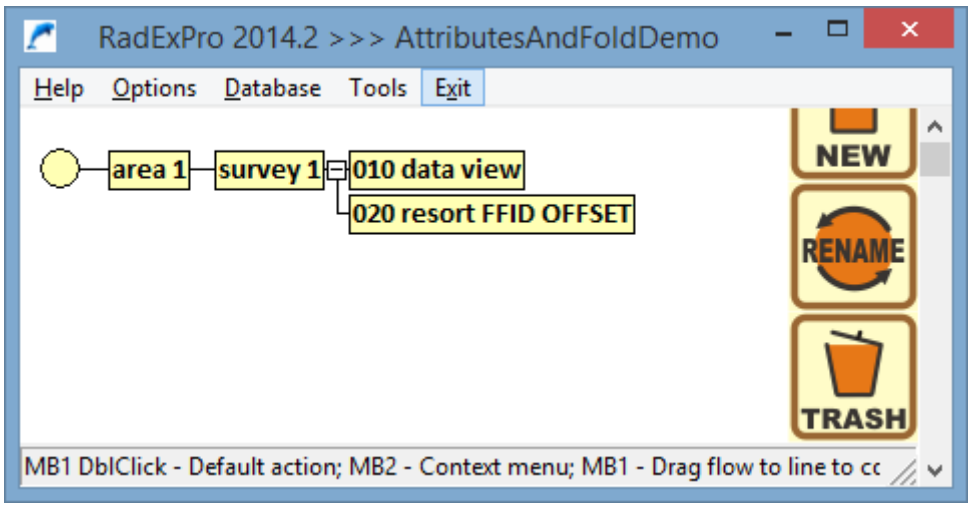
Here you can make sure that geometry is assigned to the data and that CDP numbers are properly calculated.

Since the flow is running in the framed mode, when you exit the Screen Display module by selecting **Exit** from the menu, the next frame will be launched, and its contents will be shown in the new module window. To exit the module and stop the execution of the flow, press **Exit/Stop flow** (a **Stop Flow Break** message will appear on the screen – this is normal program behavior).

Data resorting

To compute the CSP seismogram quality attributes, we'll first need to resort the data to the FFID:OFFSET domain – this will allow us to interactively define the space-time windows for various wave types.

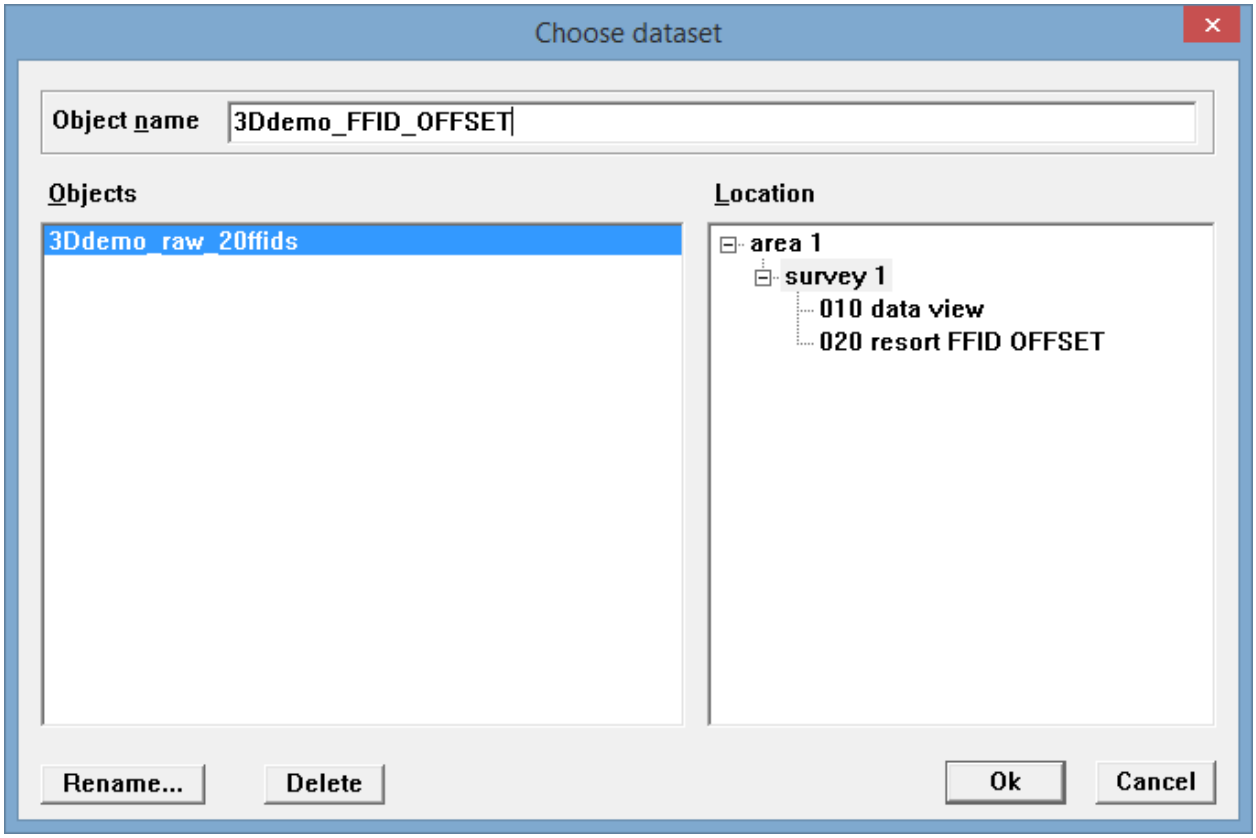
Let us create a new processing flow named **020 resort FFID OFFSET**.



Open the flow and add the Resort* module to it (asterisk after the module name means that it should be the only module in the flow). This is a specialized module for quick sorting of large amounts of data.

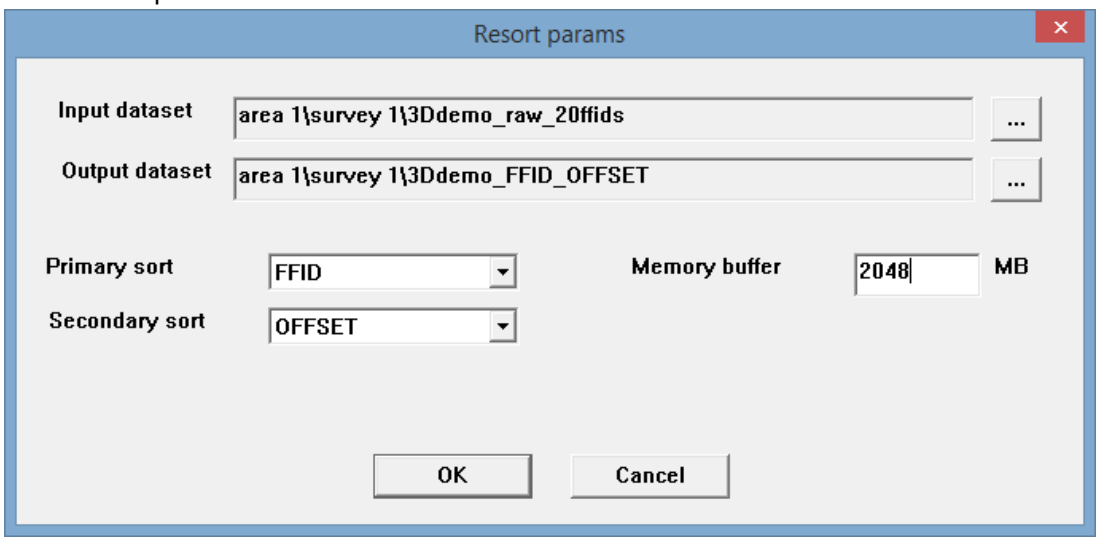
Specify the **Input dataset** in the module parameter window – 3Ddemo_raw_20ffids.

Enter the name of the resorted **Output dataset**– for example, 3Ddemo_FFID_OFFSET (we'll place it at the **survey 1** database level, where our input data are stored):

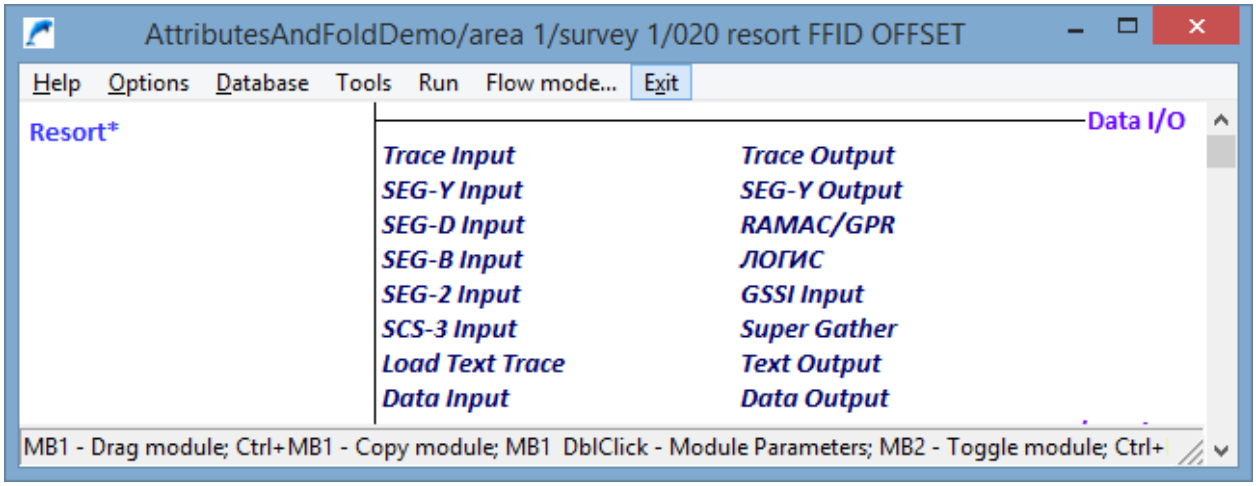


Define the Sort Fields: **Primary sort** – FFID, **Secondary sort** – OFFSET, and enter the maximum RAM buffer size to be used by the module. The buffer size should not exceed half of the installed memory capacity. In our example we'll use a 2048 Mb buffer.

The module parameter window should look like this:



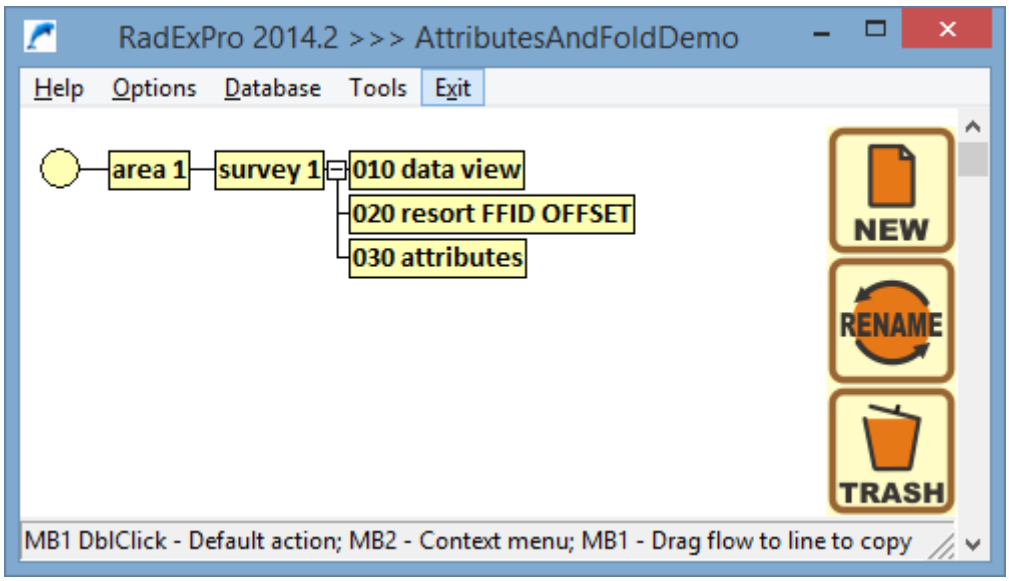
Press **OK**. Since the Resort module processes the input dataset independently, the framed flow mode won't be needed in this case. The resulting flow can be run immediately:



Defining the attribute computation windows

We want to evaluate the RMS amplitude of the signal in the target reflection zone, apparent frequency in the target reflection zone, and RMS amplitude of the microseism for each CSP seismogram. For this, we'll first need to define the space-time windows corresponding to the target reflections and the microseism. We will do it interactively in the Screen Display module.

Create a new flow – **030 attributes**:



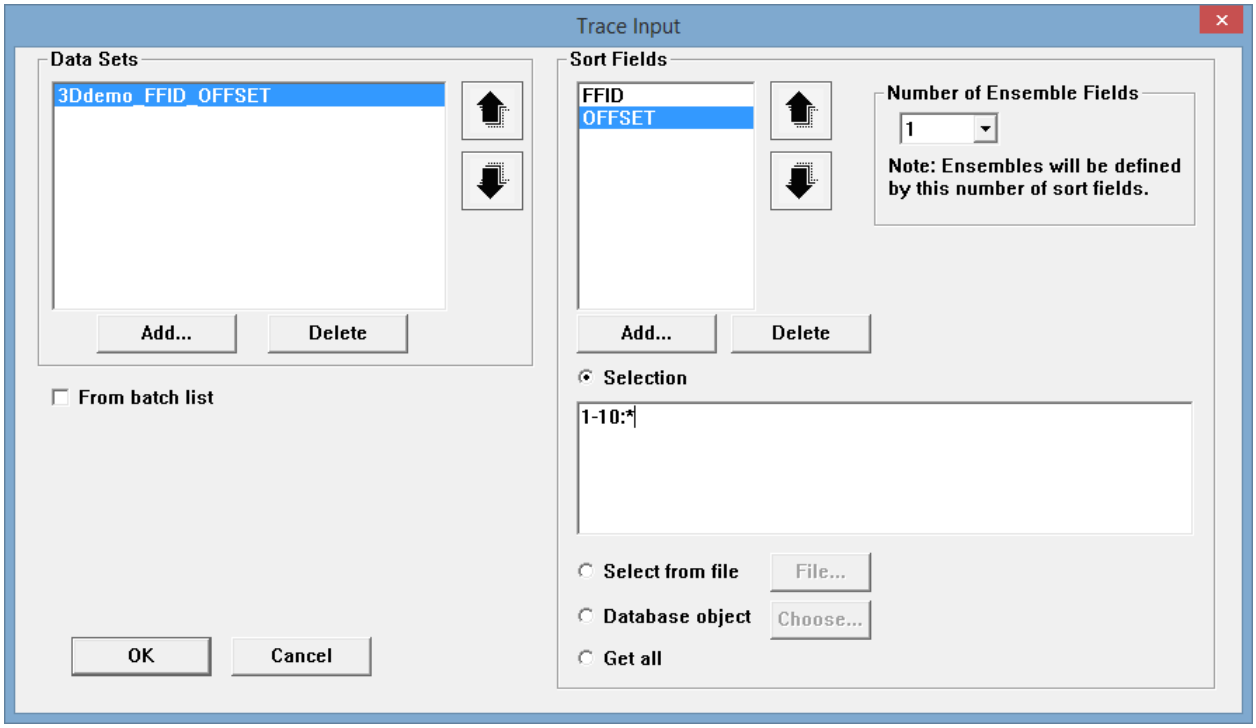
Open the flow and add the Trace Input module to it. Select the resorted data set and specify FFID and OFFSET as the Sort Fields. Since the input data are already sorted in this manner, no additional sorting and, therefore, no associated time losses will occur when reading the data.

The space-time windows for attribute computation are associated with time and offsets only; therefore, they can be defined interactively without reading all the data. Let us read the first 10 CSP seismograms and the entire offset range contained in them. To do this, specify the following trace selection mask in the **Selection** field:

*1-10:**

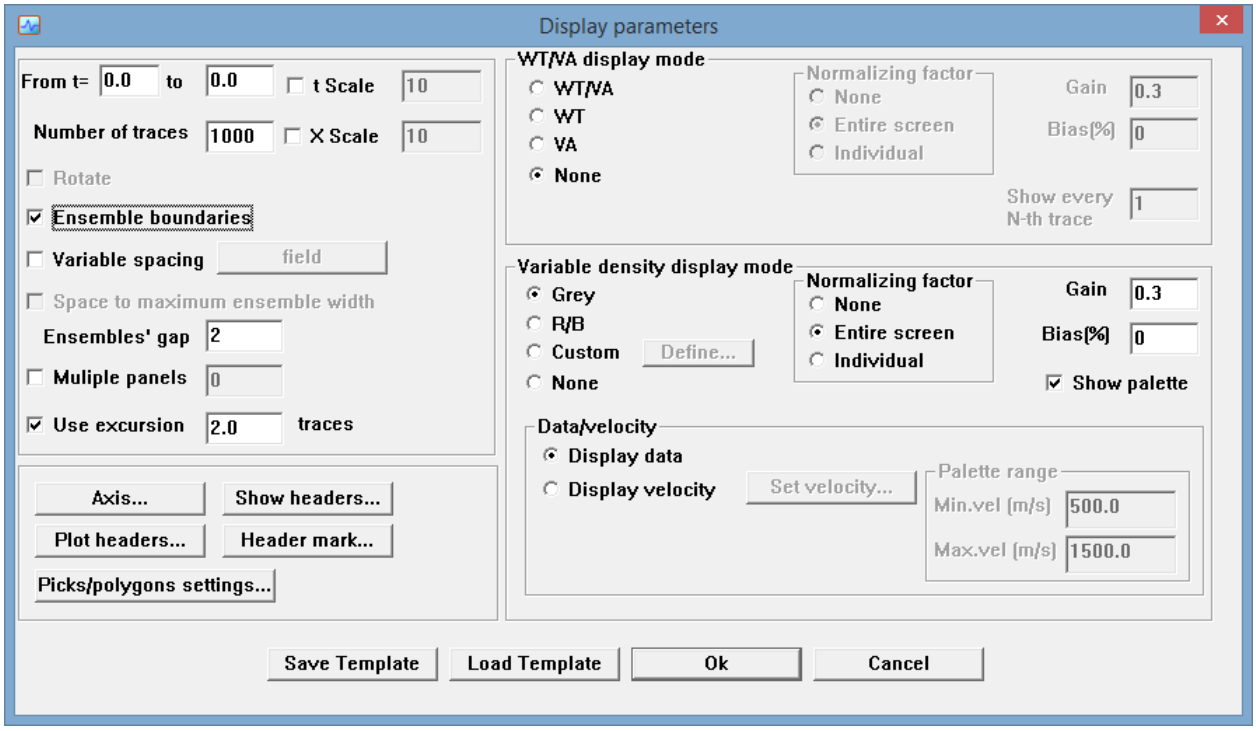
This selection mask means that only traces with the values of 1 to 10 will be selected from the **Sorting fields** list for the first header (FFID), and all traces will be selected for the second header (OFFSET).

The Trace Input window should look like this:

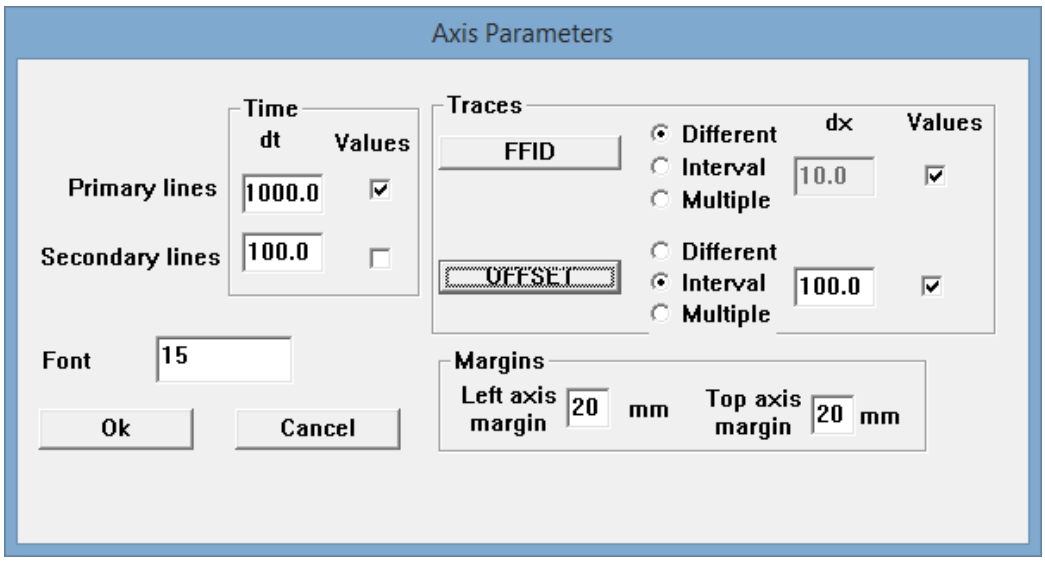


Add the Screen Display module to the flow. Set the horizontal scale (**Number of traces**) to 1000 traces per screen and check the **Ensemble boundaries** box to have the module display the gaps between the ensembles. Since the **Number of Ensemble Fields** is set equal to 1 in the Trace Input module, and the first Sort Field in the list is FFID, the software will consider each set of traces with the same FFID header value as a separate ensemble (i.e. the ensembles will correspond to the CSP seismograms in this case).

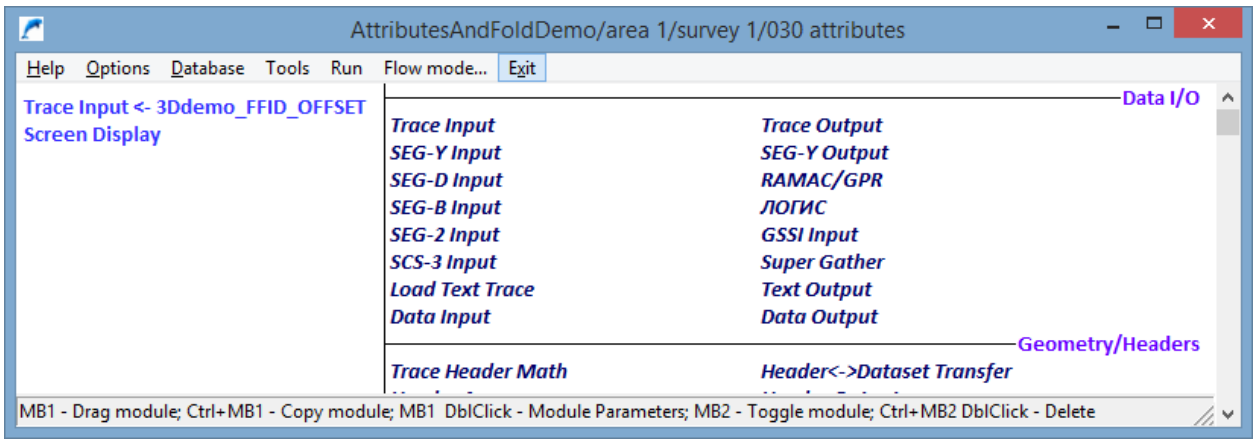
The module parameter window should look like this:



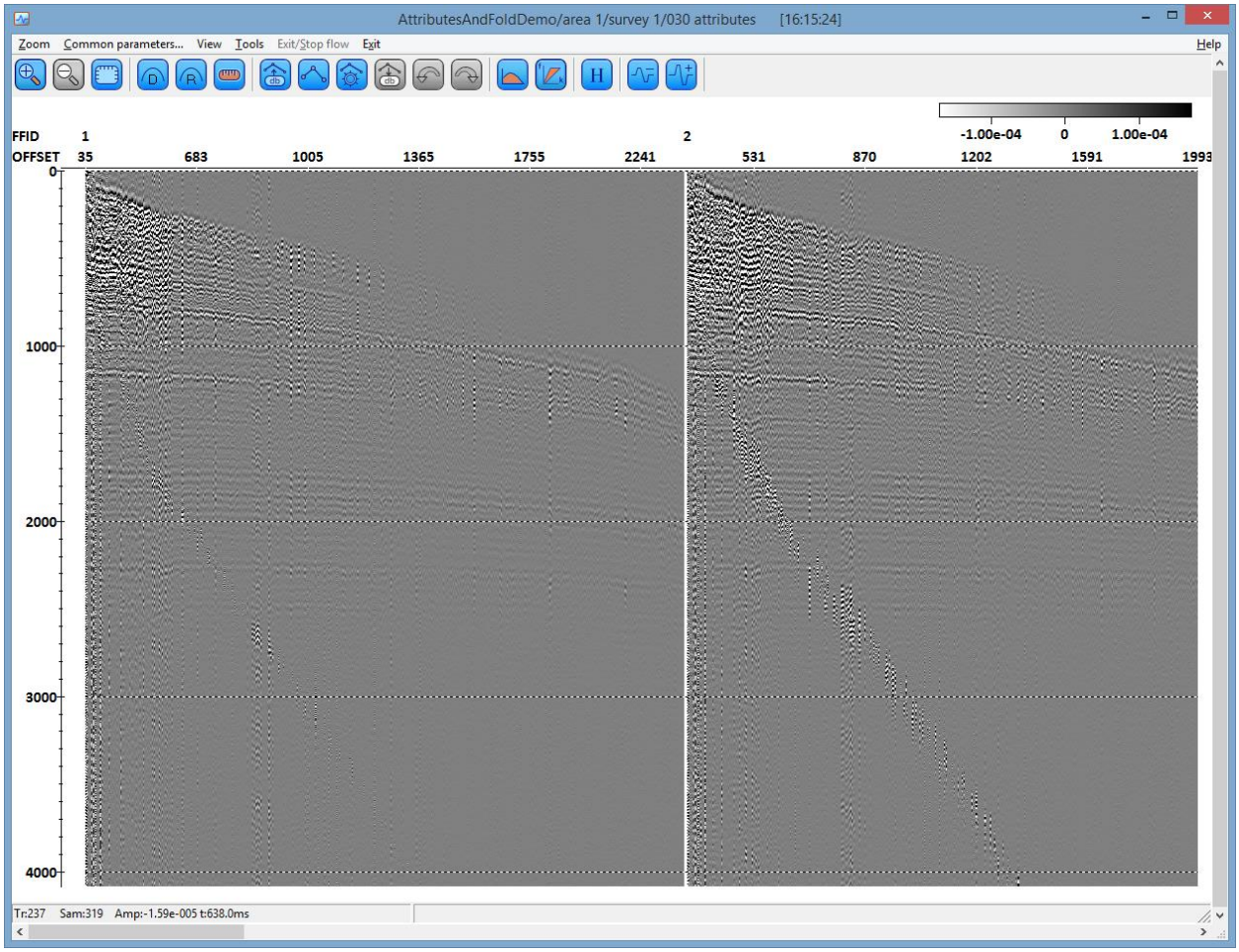
Press the **Axis…** button to set up the horizontal axis labels. We want to display the FFID values every time they change as well as the OFFSET values with the interval of 100 traces:



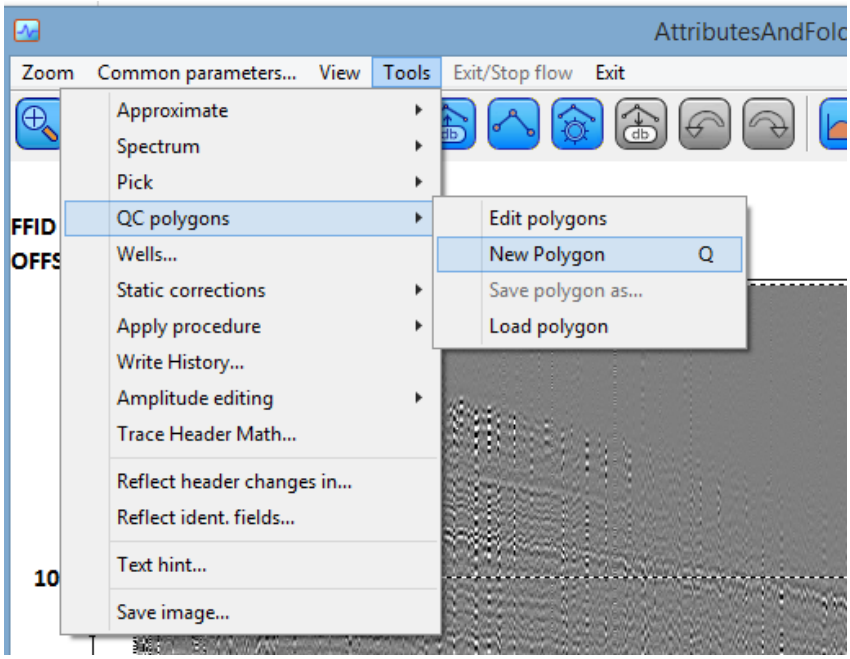
Since only a few seismograms are added to the flow, we will not enable the framed mode, and will run the flow as it is:



The Screen Display module window will open. Note that there are gaps between the seismograms:

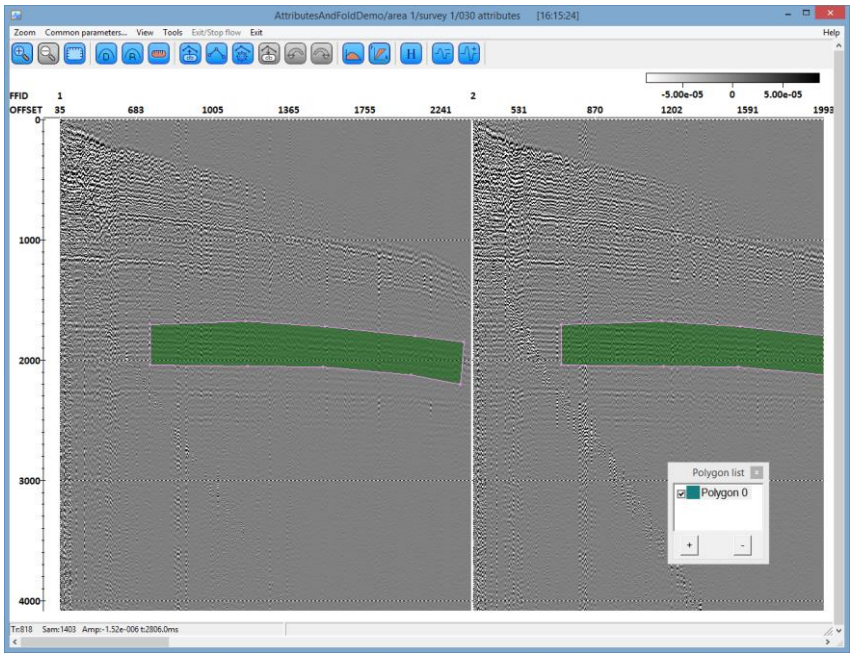


Open the **Tools/QC polygons** menu and select the **New polygon** command to create a new attribute computation window (new polygon):

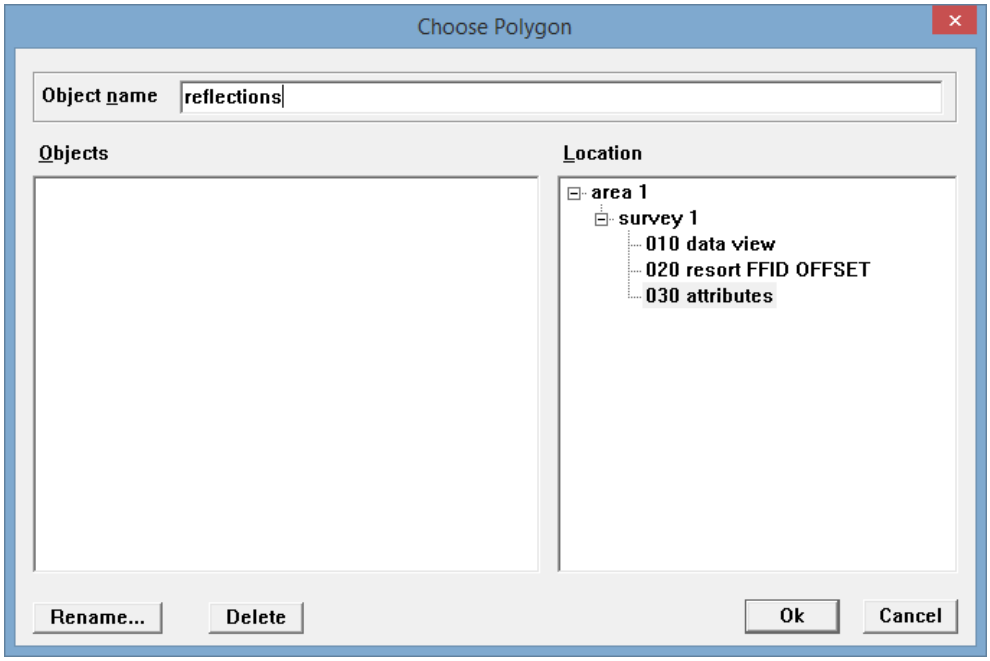


A window with the list of polygons will pop up. The polygon highlighted in the list (the newly created Polygon 0) can be interactively defined and edited on the screen:

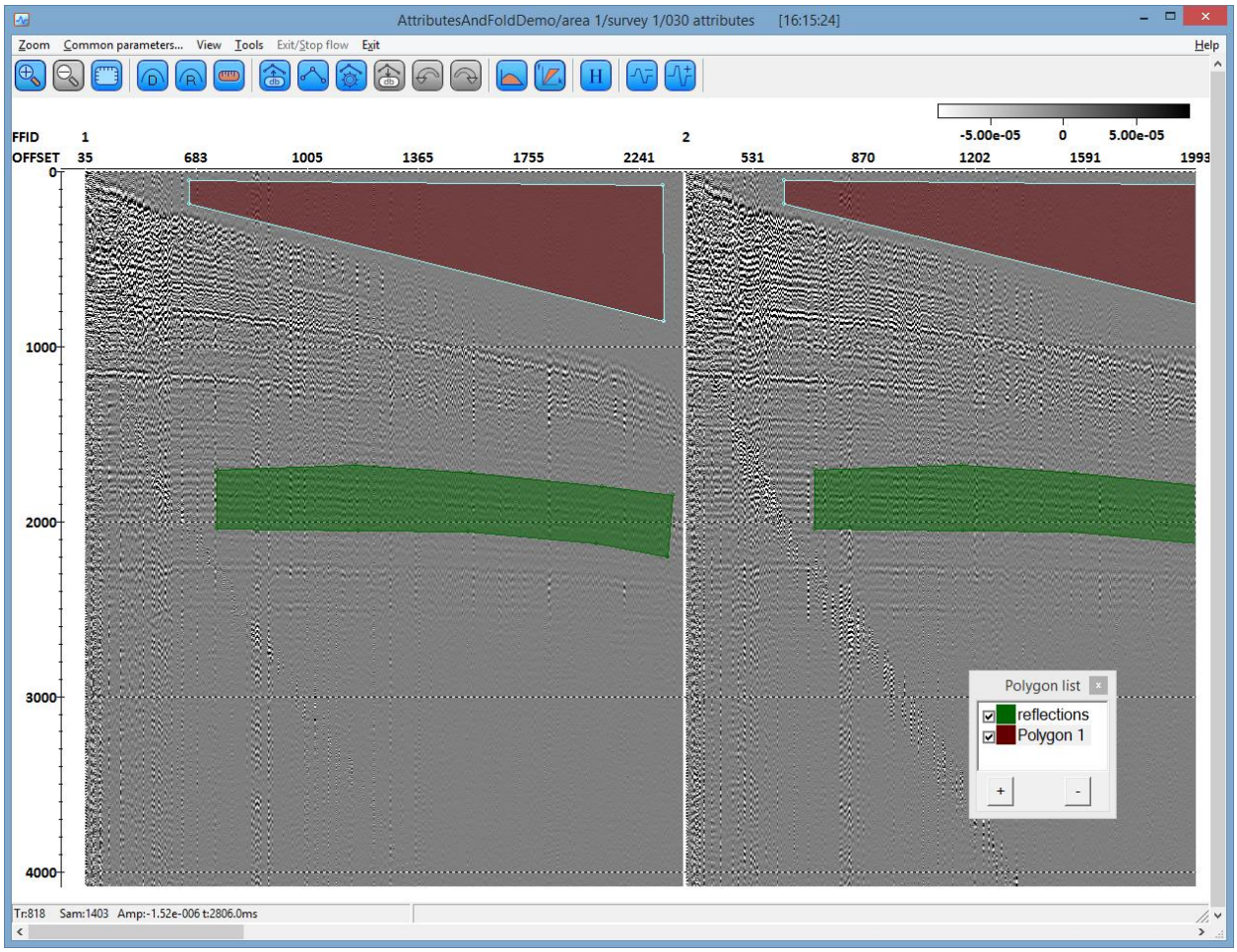
Draw the polygon around the target reflection area by left-clicking consecutively on the screen. You can define the polygon using any seismogram – it will be displayed identically on all of them:



When you are done creating the polygon, right-click its name in the polygon list and select **Save as** from the pop-up menu. Let us save the polygon to the database at the current flow level:



Now let us create another polygon in the microseism zone, above the first arrival, in a similar manner:



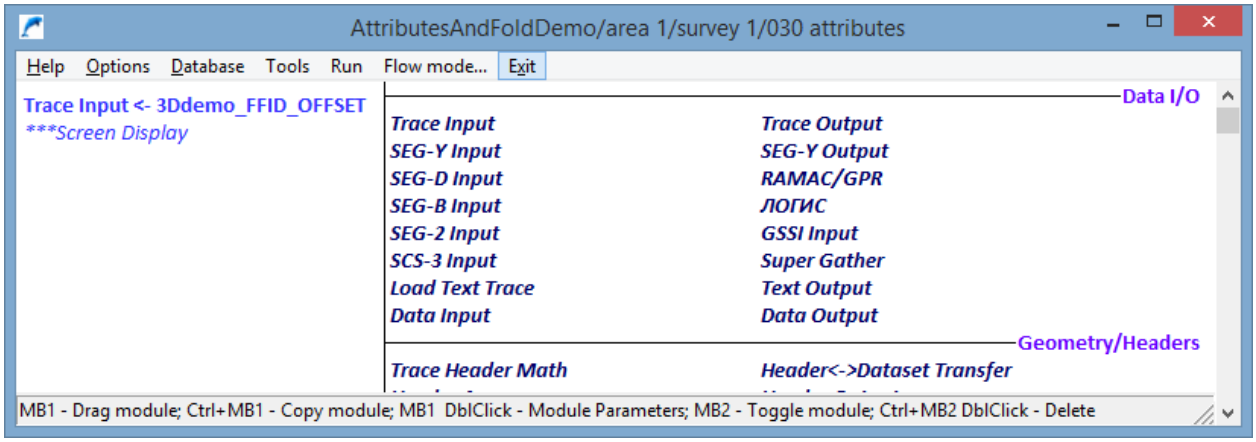
Let us save it to the same location under the name **noise**.

The window creation step is now complete. If you want, you can scroll through the Screen Display window to view other seismograms and make sure that the **reflections** and **noise** polygons are defined correctly and identically for all of them before exiting.

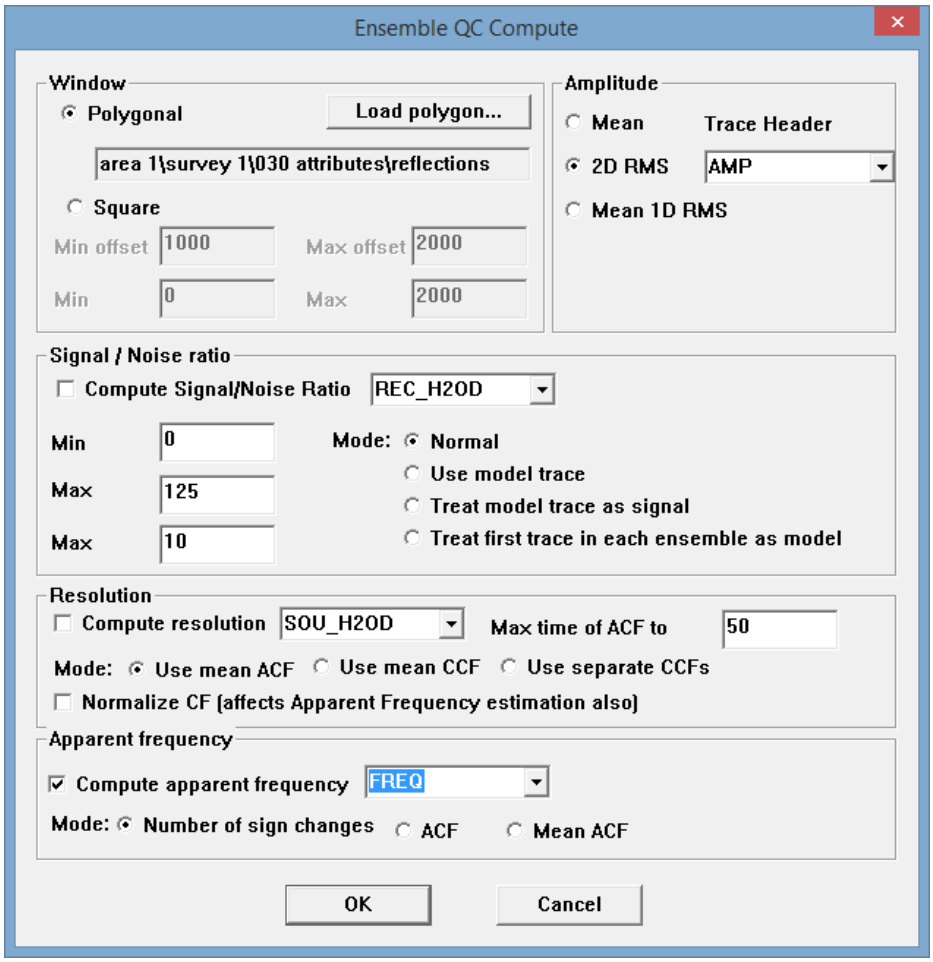
Attribute computation in the windows

Now that we have the polygons for attribute computation, we can start actually computing the attributes. We will continue working with the same flow.

First of all, right-click the Screen Display module to deactivate it ("comment it out"). This way, the module will be skipped when the flow is run:



Now let us add the Ensemble QC module to the flow. This module allows evaluating several quality attributes for the seismograms:

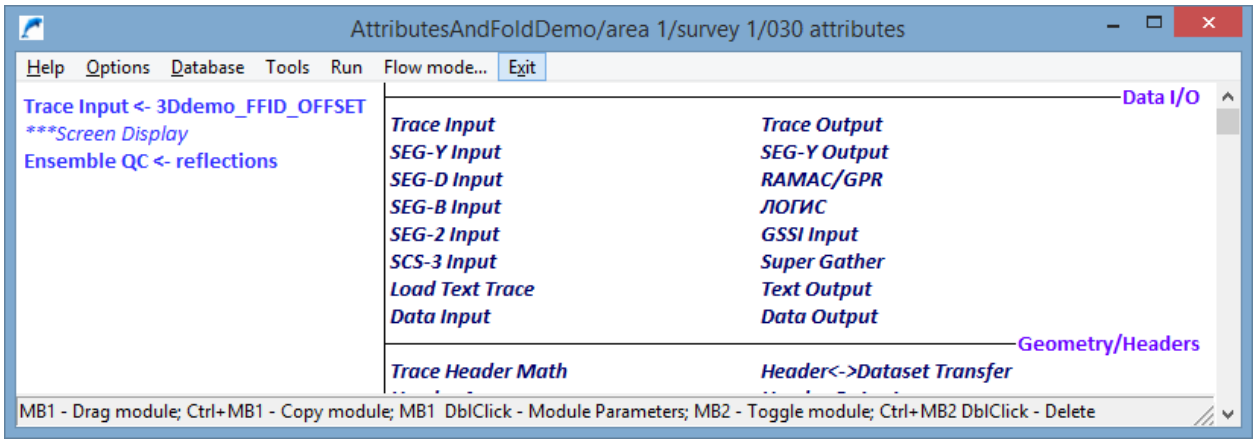


Set the parameters as shown in the screenshot above: select the target reflections polygon – **reflections** as the computation **Window** (as an alternative, you can define a rectangular window by entering the time and offset ranges). We will compute the 2D RMS amplitude values within the window and save them to the AMP header for each trace.

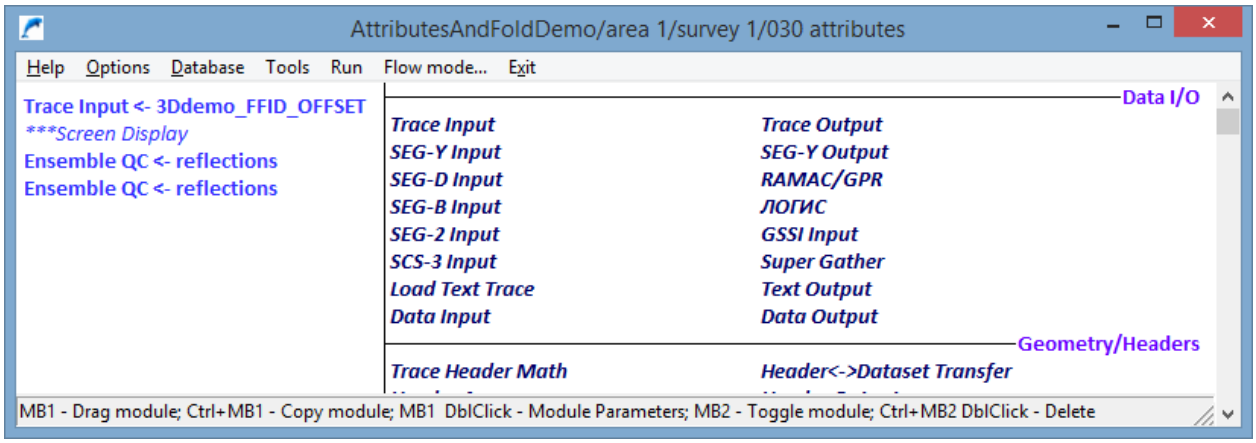
Since we are going to skip the signal-to-noise correlation ratio and resolution computation for now, uncheck the **Compute Signal/Noise Ratio** and **Compute resolution** boxes.

The apparent signal frequency will be evaluated based on the number of zero transients and saved to the FREQ header field.

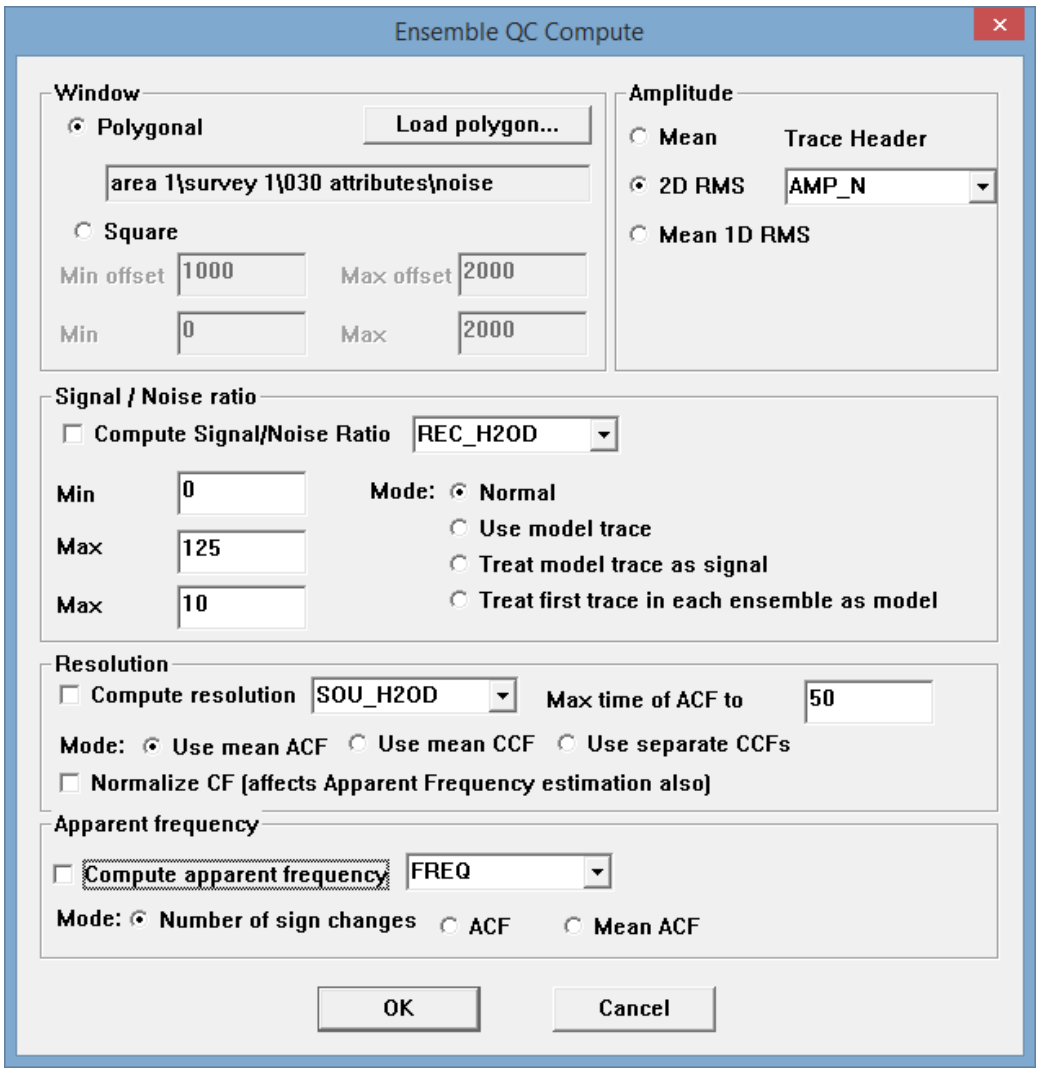
Now our flow should look like this:



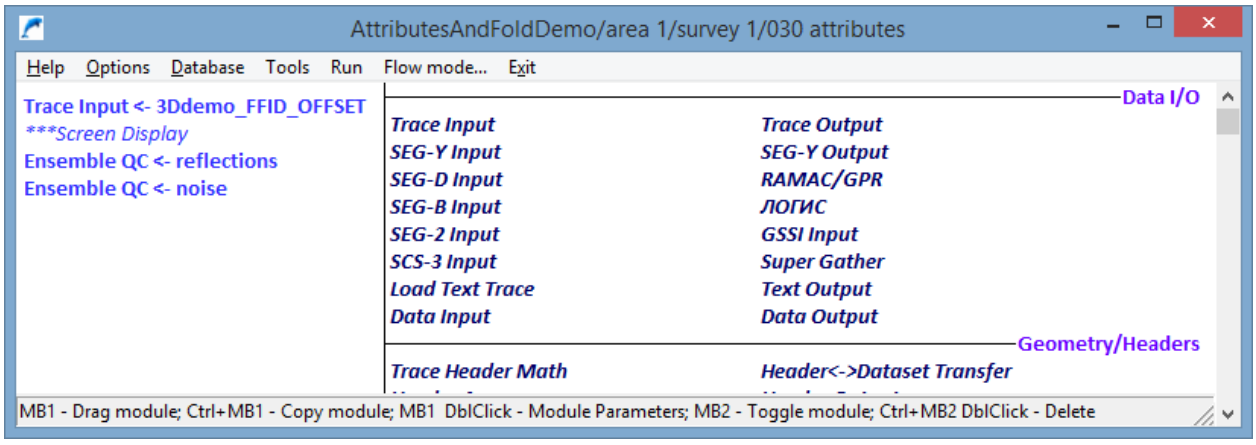
Let us add another instance of the Ensemble QC module to compute the amplitude in the microseism window. The easiest way to do it is to copy the module already added to the flow (Ctrl+click).



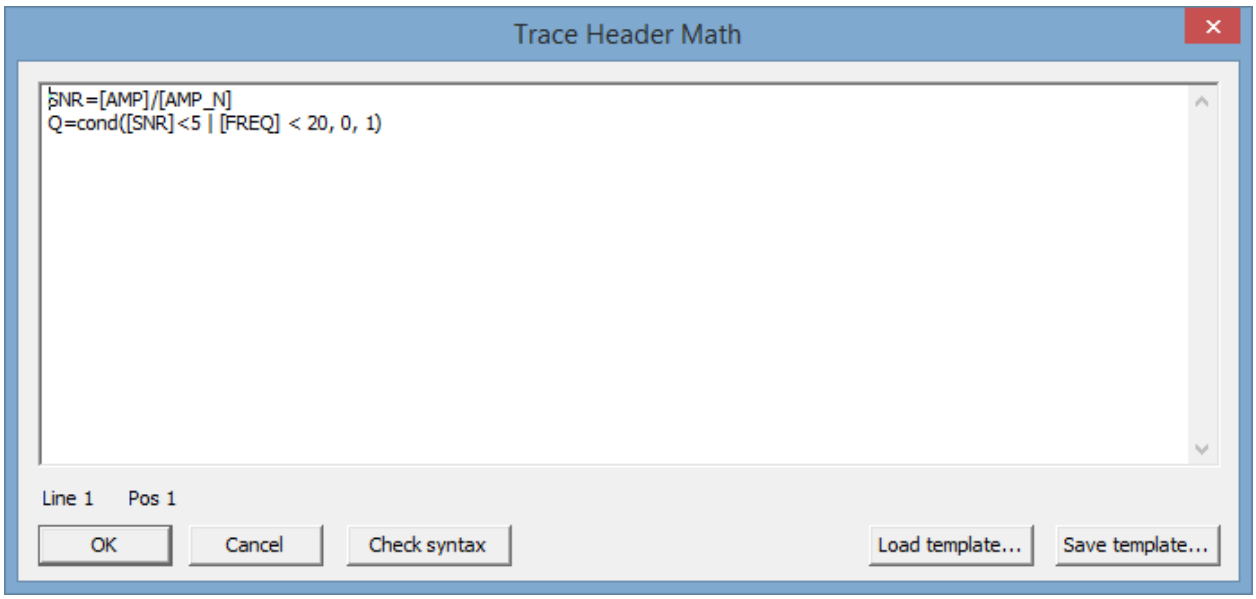
Now open the second module instance and change the parameters: replace the polygon defining the attribute computation window with the microseism polygon – **noise**. Select AMP_N as the header where the RMS amplitude values will be saved. Uncheck the apparent frequency computation box:



Now our flow should look like this:



Add the Trace Header Math module to compute the derivative attributes: signal-to-noise ratio and summary quality attribute Q which will enable quick identification of defective seismograms:



Enter the following expressions in the module editing window:

SNR = [AMP]/[AMP_N]

Q = cond([SNR] < 5 | [FREQ] < 20, 0, 1)

In the first line, the signal-to-noise ratio (SNR) is calculated as the ratio of the target reflection amplitude to the microseism amplitude.

In the second line, if the signal/noise ratio is less than 5 or the apparent frequency is less than 20 Hz, the Q header value is set to 0 (i.e. defective), otherwise it is set to 1. This is just a simplest example of how summary quality factors can be freely defined in the software. Of course, you can make such factors more sophisticated – for instance, by defining a score-based quality assessment system which best suits the survey area and the customer's requirements.

Next, we need to save the resulting attribute values (for now they exist only in the data headers within the flow). We could export them to a new dataset using Trace Output, but creating another copy of the source data just because of the changed headers appears impractical.

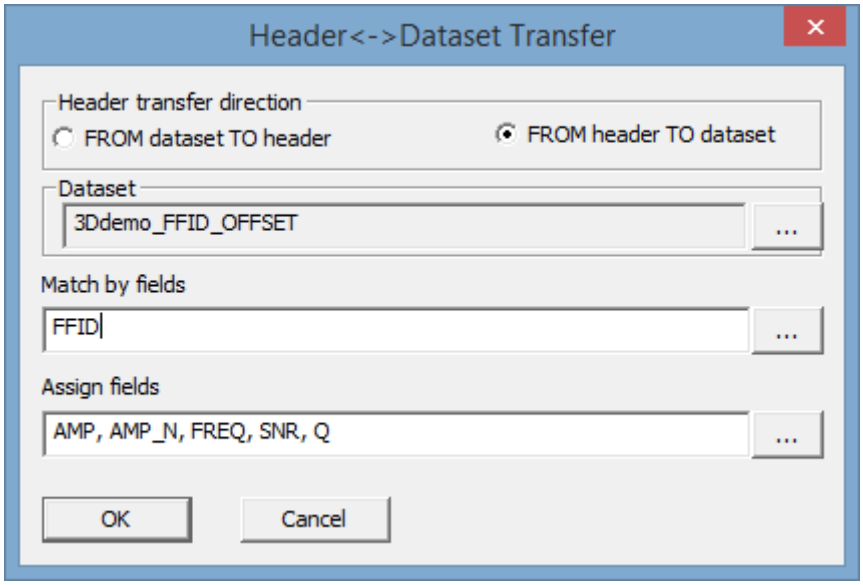
Another method that can be useful in some cases is to insert the Trace Length module before saving the data and specify the new trace length of 0. This way the traces will be truncated, and the resulting dataset will essentially contain nothing but headers. This technique can be employed if some further intensive operations involving headers only are planned – such as header smoothing, computation of derivative attributes etc.

In our example we will save the modified headers using the most convenient and universal method – by overwriting the source dataset headers with the help of the Header<->Dataset Transfer module designed for header exchange between the flow and the data stored on disk.

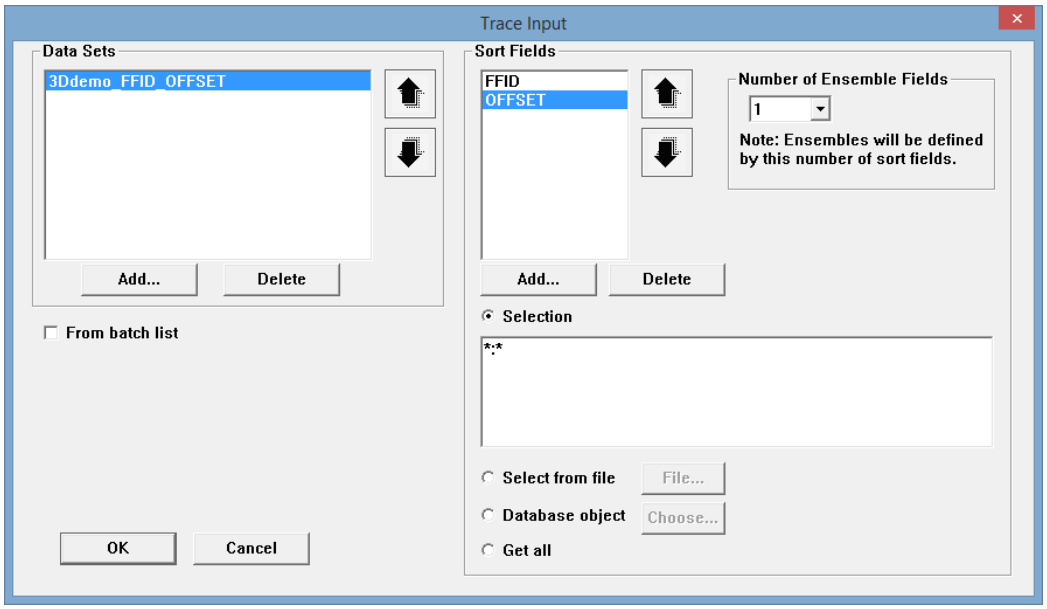
Add the Header<->Dataset Transfer module to the flow. Specify the processing direction (**FROM header TO dataset**) and select the target dataset where the headers from the flow will be written (3Ddemo_FFID_OFFSET).

Specify the headers by which the module will determine the correct trace (**Match by fields**). In this case, since the attributes were evaluated for each CSP seismogram as a whole, a single FFID header should be sufficient.

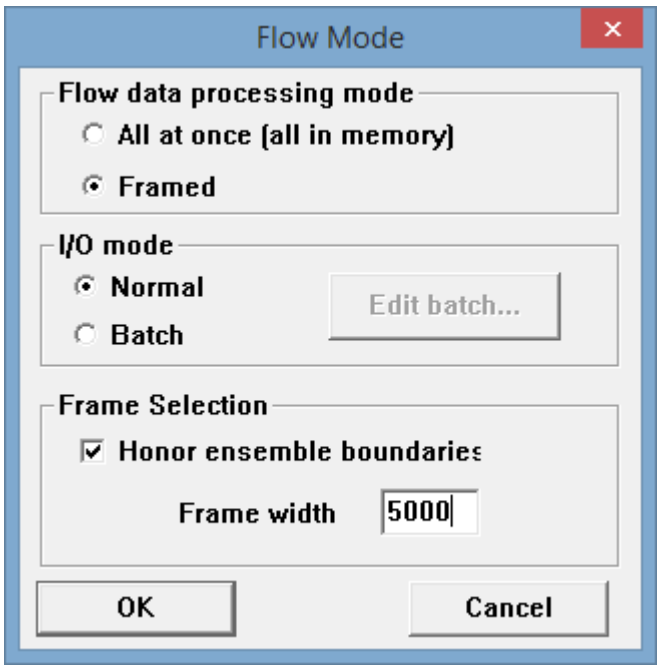
List the headers to be overwritten (**Assign fields**). These are all the attributes that we've just computed: AMP, AMP_N, FREQ, SNR, Q:



Our flow is now ready. Before running it, open the Trace Input module and disable the seismogram input restrictions since we will need all the data. Replace the selection mask with *:* (as shown below):

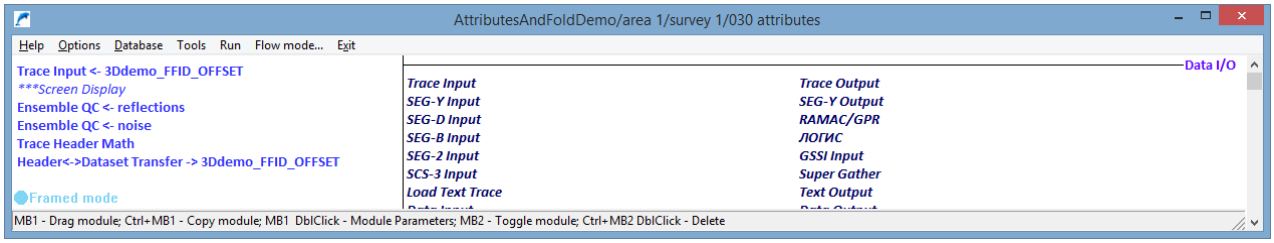


Before running the flow, don't forget to enable the framed execution mode in the **Flow mode…** menu (we are treating the data as if we were dealing with a full-scale 3D survey):



IMPORTANT! This time make sure that the **Honor ensemble boundaries** box is checked. We don't want the seismogram to be split in the middle along the frame boundary in the process of attribute computation!

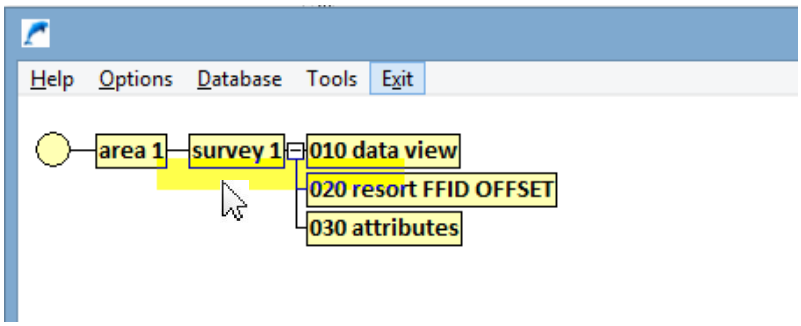
Run the final flow:



After the flow is executed, you can view the completed header fields using the Geometry Spreadsheet tool if you like.

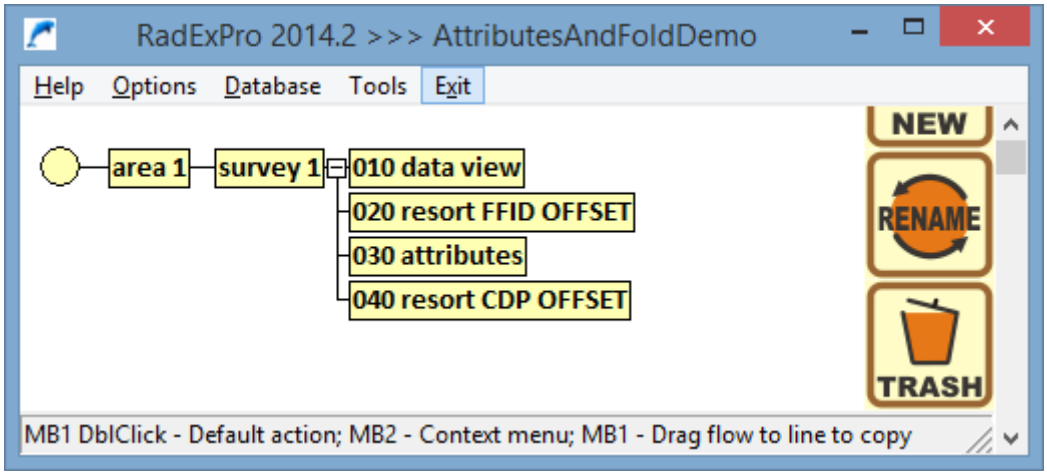
Fold computation

Before computing the fold, we need to resort the data to generate CDP seismograms. Let us create a new flow – the easiest way to do it is to copy the existing sorting flow and change its parameters. Click and hold the flow with the mouse cursor and drag it onto the **survey 1** box:

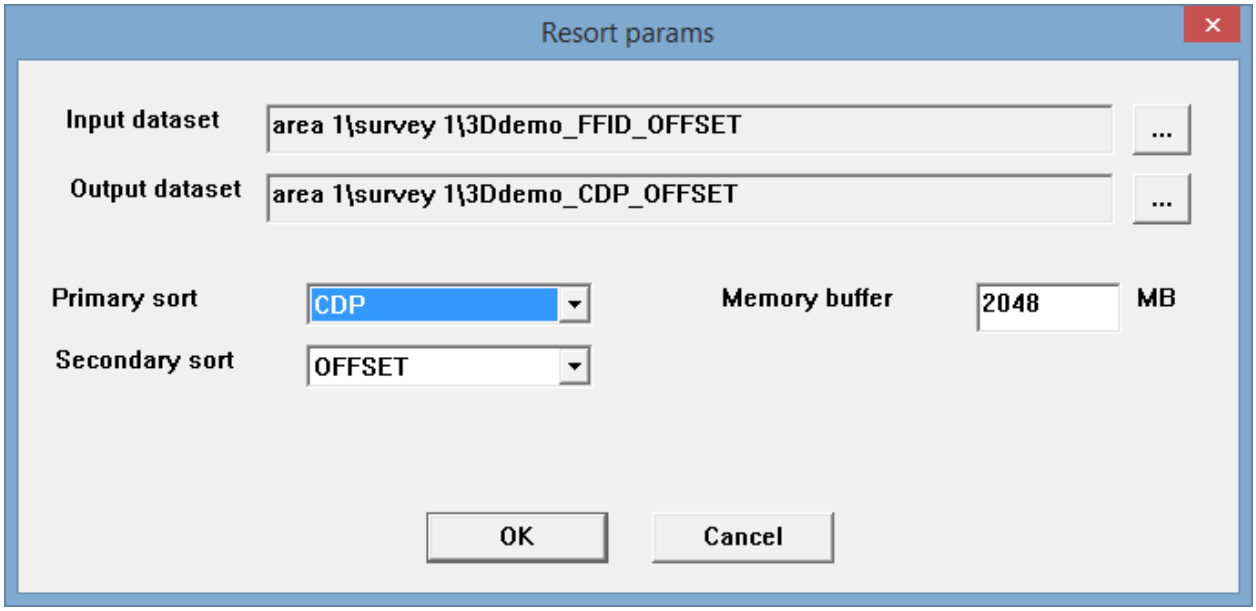


A dialog box will open, prompting you to enter the new flow name. Let us name it **040 resort CDP OFFSET**:

A new flow should appear in the project tree:

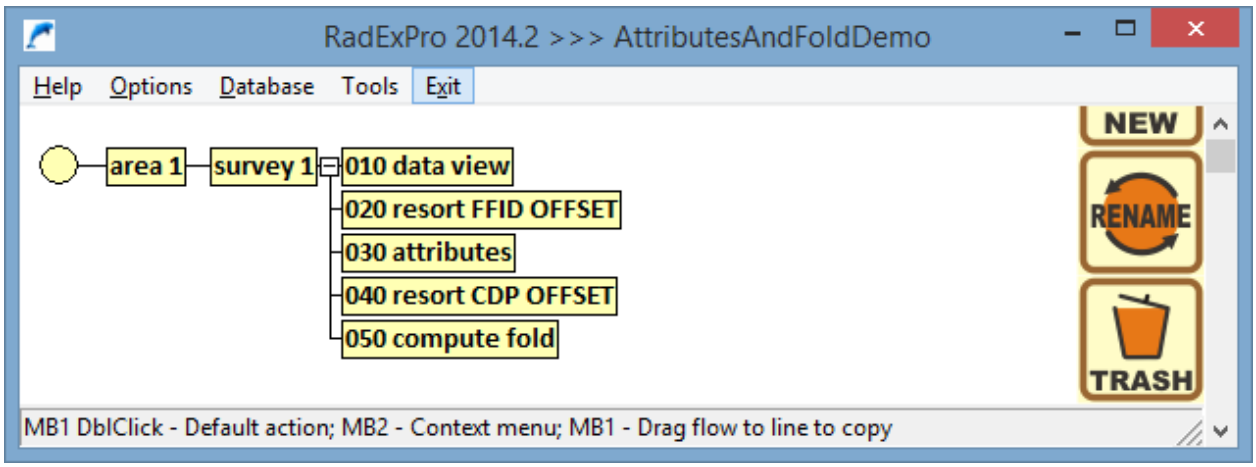


Open it and change the Resort module parameters – input and output dataset name and primary Sort Field:

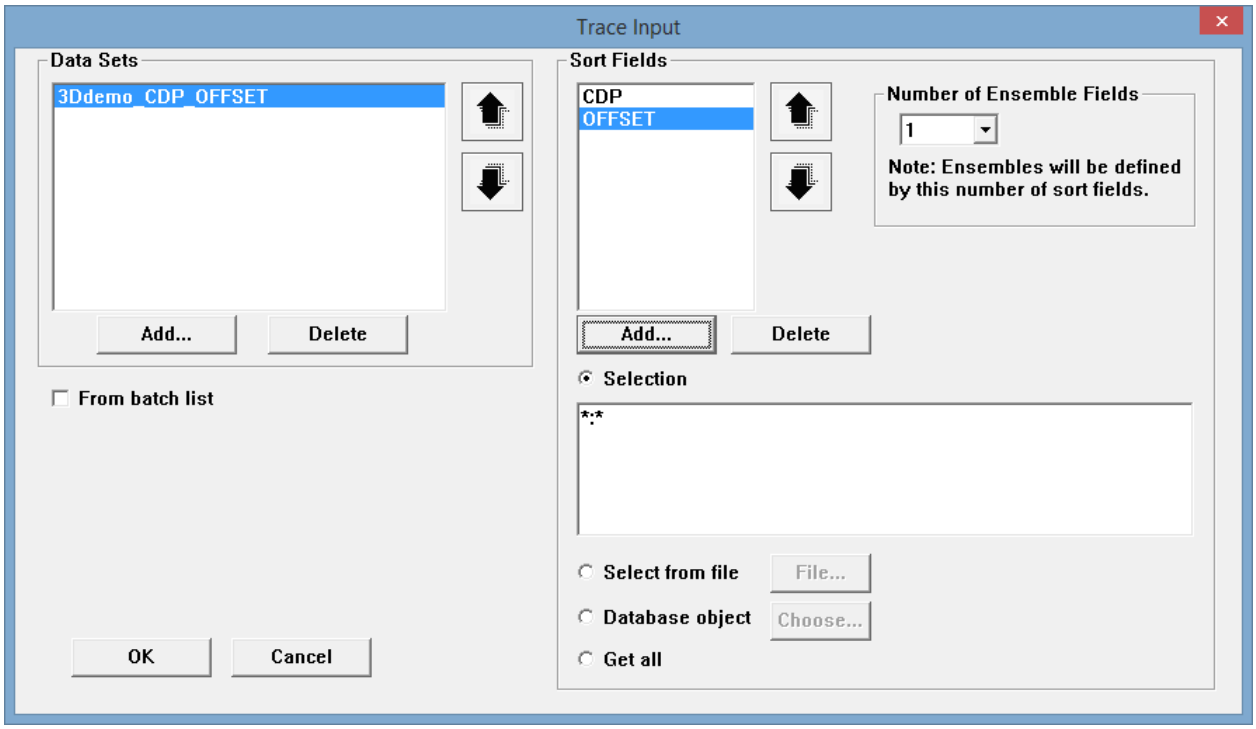


Run the flow to generate the new dataset sorted by CDP: OFFSET.

Now let us move on to the fold computation itself. Let us create a new **050 compute fold** flow for this purpose:

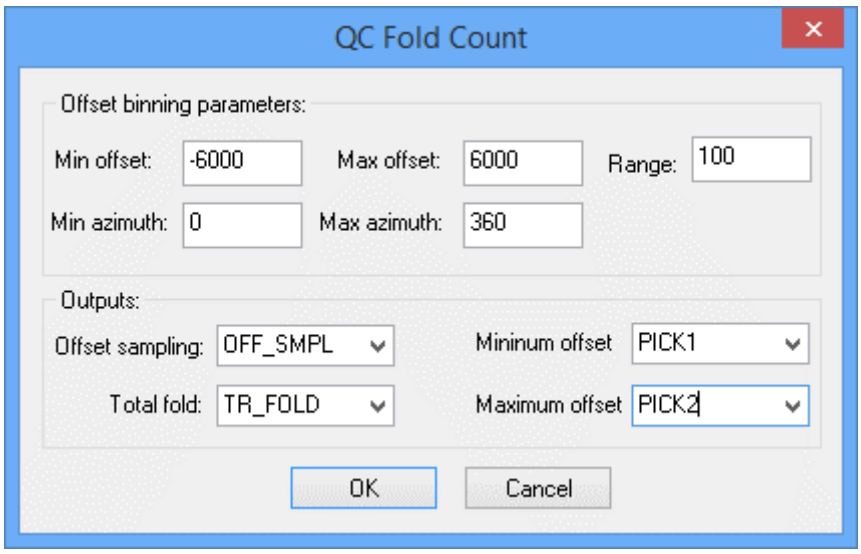


Add the Trace Input module to the flow (specify 3Ddemo_CDP_OFFSET as the input dataset and select its current CDP: OFFSET sorting in the **Sort Fields** field to generate the CDP seismograms):



Now add the Compute Fold module. This module allows computing both the Total fold – the number of traces in each input CDP ensemble, and Offset sampling – the number of non-empty offset bins in each CDP ensemble.

Specify the following module parameters:

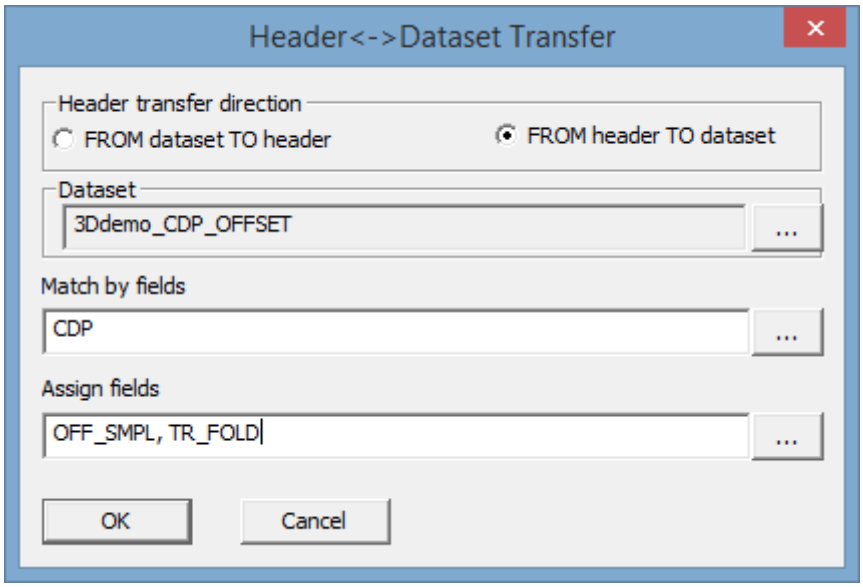


In this case the offset binning range selected for the offset sampling computation is a priori larger than the actual range available in the data, the offset bin size is set to 100 m, and the full azimuth range from 0 to 360° is taken into account.

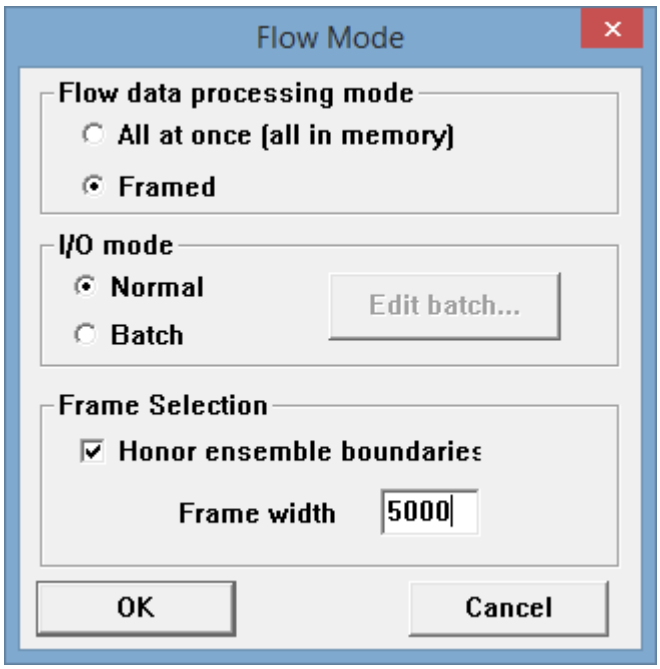
The offset sampling values will be saved to the OFF_SMPL header, and the total fold values – to the TR_FOLD header.

In addition, the module saves the maximum and minimum offset values encountered in the ensemble for each ensemble. Specify any 2 unused headers for this purpose – for example, PICK1 and PICK2.

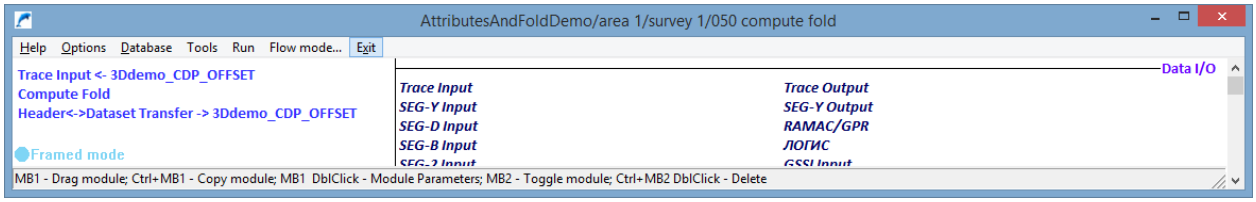
Finally, let us save the total fold and offset sampling computation results to the input dataset header. We'll use the already familiar Header<->Dataset Transfer module for this:



The flow is ready. Don't forget to enable the **Framed mode** before running the flow. The **Honor ensemble boundaries** box should be checked, since each CDP seismogram is to be processed in full:



The final flow should look like this:



After the flow is executed, you can view the completed header fields using the Geometry Spreadsheet tool if you like.

The next step – mapping – is covered in the tutorial on Working with crossplots in RadExPro – seismic survey map, fold and offset sampling maps, and signal-to-noise ratio map.