

# Processing Ramac GPR Data with Reflex - 5/3/2010; Steve Sheriff

## Initial Filtering and 2D analysis

1. Make the file names of your Mala GPR data numerically sequential (100, 101, ..., 135).
2. **Start Reflex,**
  - Declare your project directory and Reflex will make its own (required) subdirectories under the project name directory.
  - Copy your .RAD & .RD3 files into the newly built ASCII subdirectory.
  - Select 2D data analysis, and then import/convert the .RD3 Ramac files to Reflex format; think about the import parameters. Make sure the file name is set to MALA RD3 in the convert window; the ROHDDATA directory will now hold your data files in Reflex format. IMPORT can be done in batch mode by selecting Conversion sequence = Parallel Lines in the Data Import window. I set Specification = original name.

If you have an array of files, for each processing step make sure you have the Sequence Processing window open. In that case, once you decide on a processing step's parameters, you can add it to the sequence and batch process the remainder of your files. That usually works well, but individual attention to each file is probably better.

**Each of the following steps requires some experimenting.** Once you get the parameters that work best, use the 2 → 1 switch (upper left) to make the processed image the new image to be processed. You can experiment until you get it correct before swapping the image in. Then, add the step to your sequence processing list.

3. **Dewow the data** (1D filters menu) to remove any very low frequency components. Typically, use the principal period of the signal which is usually a bit lower than the antenna frequency. The Pineview Park data, collected with the 500 MHz antenna, had a central frequency of about 333 MHz and a principal period of about 3 ns. Measure a couple cycles to get the principal period and experiment a bit (alternatively, use remove DC shift).
4. **Gain the data.** Sometimes energy gain is good, other times AGC works. Typically, I end up in manual y gain, decrement the direct and coupling energy, and amplify the zone I am interested in. This takes some experimentation. You must save the Y-gain file when you get it the way you want it.
5. **Move Starttime.** Reflex puts  $T_0$  ( $z=0$ ) at the start of signal so the first arrival typically is a couple nanoseconds down section. You want the first arrival to be at  $T_0$  ( $z=0$ ). In Static Corrections, choose Move Starttime (alternatively use static correction), open the wiggle window (View Wiggle Window), and determine the time to subtract from the section to get  $T_0$  &  $z_0$  correct. On one 500 MHz section, it was -1.76 ns.
6. **Correct the max phase** (optional) in a zone near the coupling and direct energy. If you flatten on one of these, the data sometimes look a little better; not always! This is often useful when the ground is rough. I do it over a wavelength (+/-) or so; experiment, if it improves the file use it. It takes a lot of fiddling. However, it helps some profiles more than others and in batch processing you can end up with a couple worse off.
7. **Background Removal** (optional). Apply it and decide. Curved and dipping reflectors will be enhanced, horizontal reflectors (foundations, living surfaces, paleosols, etc.) may be attenuated.

8. **Band pass filter** the data. Use the mouse pointer to look at the spectrum, remember the frequency is almost certainly much less than the antenna frequency. For the 500 MHz data from Pineview I used {80,160,600,625} for a central frequency of 333 MHz from the 500 MHz antenna. In the new version of Reflex, you can click on the spectrum to get the Butterworth values.

9. **Average a few traces** (optional) and/or time steps in the 2D average filter. This can really smooth things up and make features more visible. On the Pineview data I averaged across 4 traces and 5 samples (about  $\frac{1}{4}$  wavelength).

10. **Migration** (diffraction or another) can help clean things up a bit too. But, it typically takes me a few experiments.

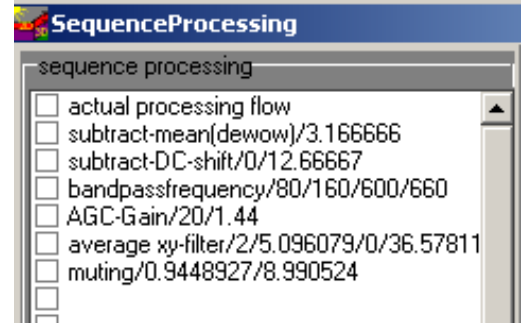
11. **Others?** Experiment! Sometimes you'll want to flip files end for end, mute the upper part of the signal, do a topographic correction, or cut off time for depths greater than interest. I also used the Edit Traces/Extract and then Export features to take individual profiles out of a file where students had collected several profiles as one concatenated file.

### **Save your Processing Sequence!**

12. You can export Ramac files once you have them processed in Reflex (why?) but the header files leave out some pertinent information. Yet, you should have the original header anyway so use it, and copy the pertinent parameters.

## To Batch Process

Once you have a saved processing sequence, select Processing/Sequence Processing, load the sequence you saved, and 'open several 'files'. You can look at the results one at a time or up to four at a time in the 2D module with File/Open 1-4 lines; you can look at a6 or more at once in the 3D module.

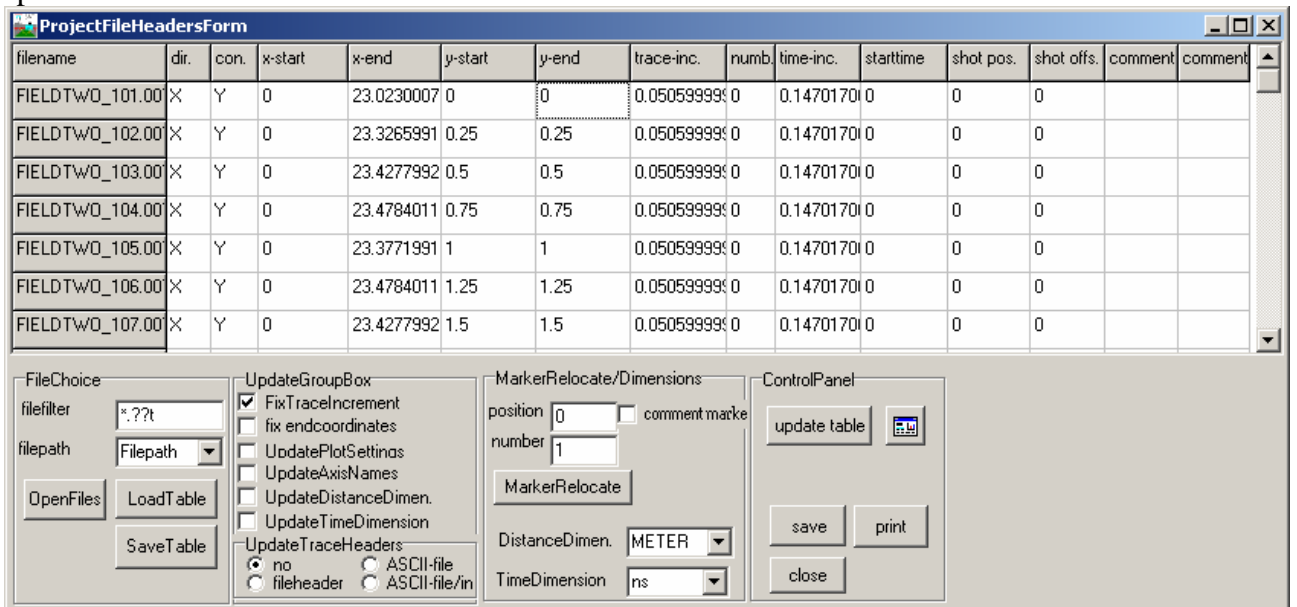


When viewing results, scroll through the palette options – different palettes often make features more/less apparent.

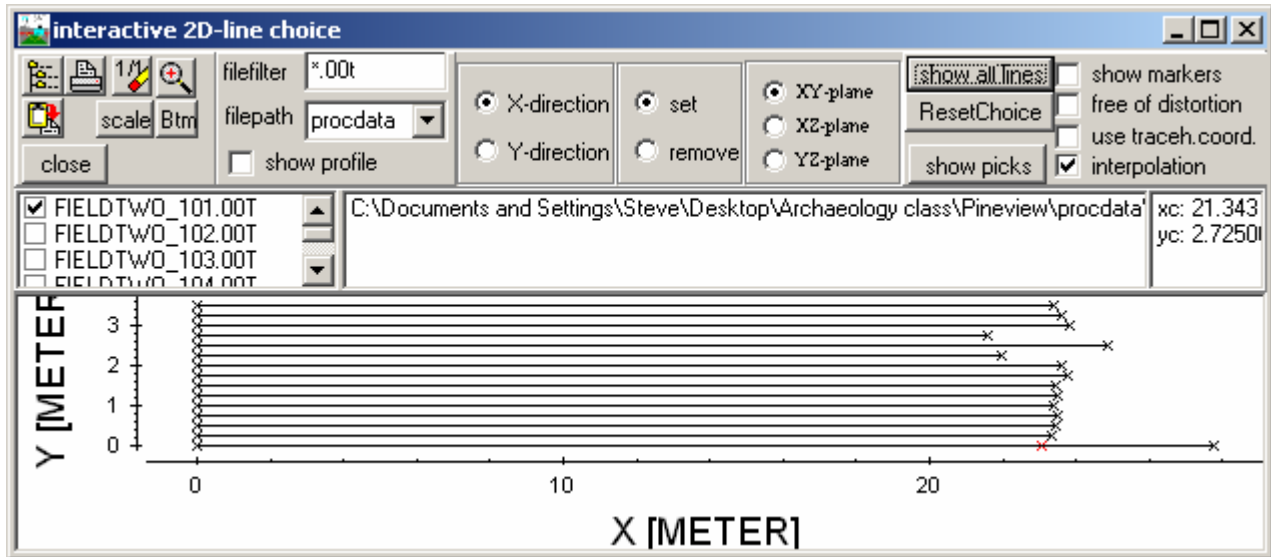
At this point, I often delete all the files in PROCDATA and run the batch processing again. I do this because REFLEX saves lots of files and if you reduce the directory so it only includes the ones you want, later steps are easier.

**In 2D Data Analysis** you now need to rectify the profile coordinates.

- use **EditSeveralFileHeaders** to open the headers of your processed 2D lines. Here, you have to manually enter the y-coordinate for each line. This is because Reflex will also process unequally spaced lines.



- Use **File Open, Interactive Choice** and hit the “Show All Lines” button to get a geographic layout of the lines as understood by the headers. If you were careful in the field these should all be nearly the same length. If you need the detail and ‘clean look’ you can crop the long ones with Edit Traces/Trace Ranges.



### 3D Visualization

#### Start the 3D module

File/Generate 3D file from 2D lines; fill in the name, line increment and ‘Load 2D Files’, select your processed files (in PROCDATA) and hit ‘Start’.

Select Y-CUTS and hit the PLOT button – you should see an array of your processed files.

Select **3D cube**, and change ‘scale x’ and ‘scale y’ so the prism is a reasonable size.

Select **Scroll** – hit PLOT.

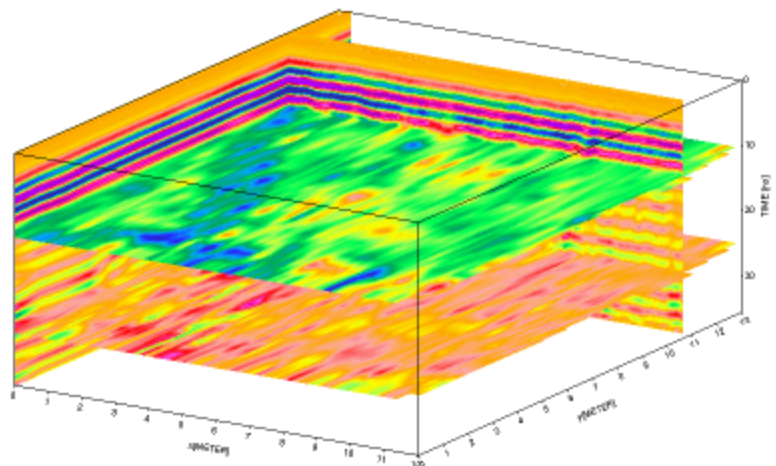
You can now scroll through x-slices, y-slices, or time slices; look at your results.

Processing (on menu bar) – **ENVELOPE TIME SLICES** will often help the results, as will the median filter and sometimes sharpen edges.

Scroll and play.

Selecting **SINGLE** and various x, y, and time cuts sometimes is good for display. Try a few palettes.

Select the FULL button, and the ‘y’ interpolation radio button; hit PLOT. This can take a while and is a kluge – it seems to need to re-plot at every move; it seems pretty klunky.



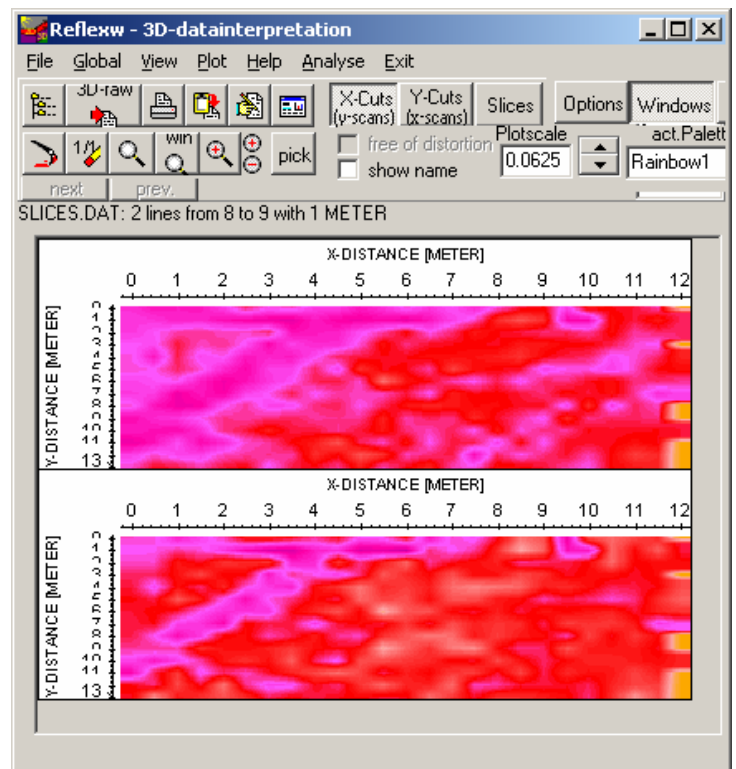
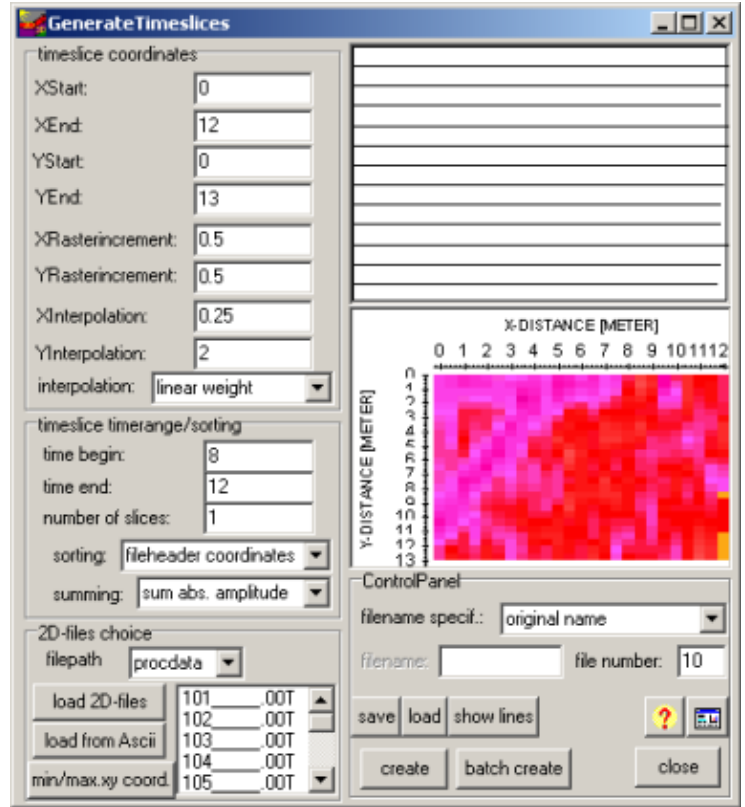
## Making 3D time slices once you have processed 2D lines

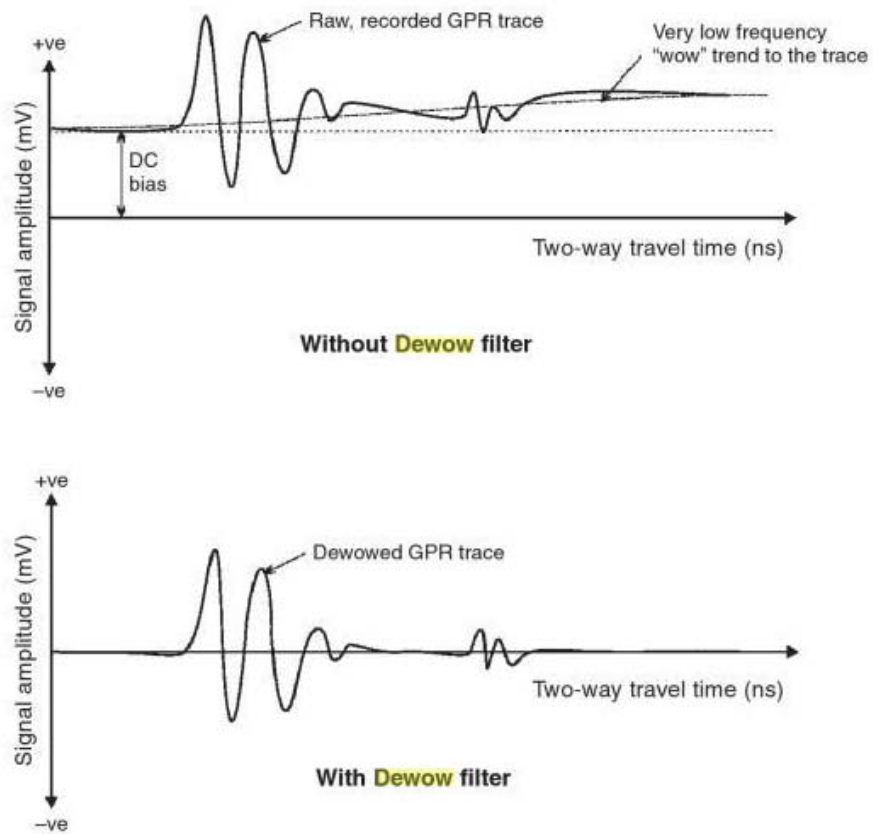
In the 3D Data Interpretation module:

- **File/Generate Time Slices**, and load your 2D processed files.
- Fill out the time slice coordinates. The x and y raster increments can be equal to the trace separation. The x and y interpolations have to be big enough to cover the data. Thus, the minimum values for these parameters are the trace separation for x, and the line separation for y.
- Determine and enter the thickness (in time) for the times slices you want to create. This takes some experimentation and depends on what you might be looking for. For something of the scale of graves, try about 10 ns to start: experiment: 3ns, 5ns... Sort by File Header Coordinates and typically use Absolute Summing. I recommend reading the help file for the program.
- Hit **Create**.
- You can **view the results** in the 2D or 3D data analysis modules.

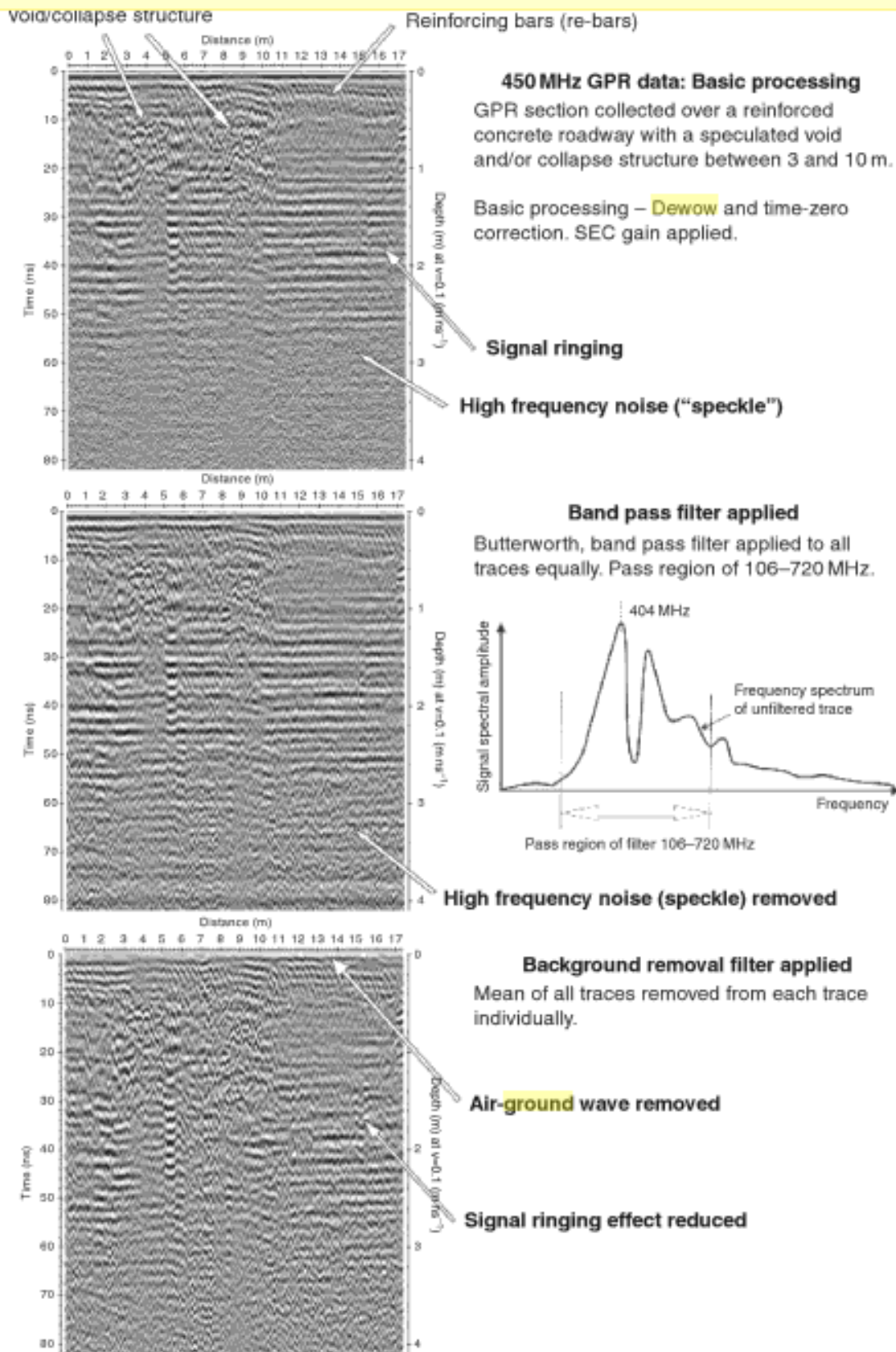
In the 3D module, File/Open Several 2D files, X-Cuts, PLOT, and proceed.

In the 2D module, use file/open 1-4 lines to see 4 at once. In 2D, EditSeveralFileHeaders will let you see which file is which.





**Figure 5.3** Dewow filter correction on a raw ground penetrating radar (GPR) trace.  
From: Ground Penetrating Radar: Theory and Applications, H.M. Jol, editor, Elsevier Press, 2009.



**Figure 5.6** Realistic example of the use of temporal band-pass and background removal filtering on a 450-MHz ground penetrating radar (GPR) section collected over a reinforced concrete roadway with a speculated subsurface void/collapse feature between 3 and 10 m. From: Ground Penetrating Radar: Theory and Applications, H.M. Jol, editor, Elsevier Press, 2009.