Newsletter - August 2018

GPR-SLICE Subscribers,

We would like to welcome the following organizations to the GPR-SLICE community

- GeoRADAR NRW GmbH, Germany
- SismoTerra, Spain
- Dept of Civil Engineering, Unversity of Texas at Arlington
- Historic Environment Scotland, United Kingdom
- Ayed Eid Al Osaimi Geotechnic Co., Saudi Arabia
- Metropolitan Police, United Kingdom
- Busan Metropolitan City, Korea
- Civil Engineering, University of Ositek, Croatia
- School of Archaeology, University of Oxford, United Kingdom
- George Washington Birthplace National Monument, NPS, Fredericksburg, Virginia
- Dept of Antrhopology CRAG, Colorado State University, Ft Collins
- Kozo Keikaku Engineering Inc, Tokyo, Japan
- 3DSoil, Belgium
- Corporacion Ambiental de Mexico, S.A. de C.V.
- Chien Hsin University of Science and Technology, Taiwan
- State Geological Survey, University of Illinois, Champaign
- Dept of Minerals and Mining Engineering, Virginia Tech
- Dept of Anthropology, University of South Florida
- Cemetery Coordinator, Oklahoma

- Envirolift, Canada
- Instituto Politecnico Nacional, Mexico
- Golder Associates, Colorado
- Roads and Maritime Services, New South Wales Government, Australia
- Civil and Environmental Enginneering Dept, Strathclyde University, Scotland
- Municipality of Essen, Germany
- WSP Canada Inc, Calgary
- Paradigm Consultants Inc, Houston, Texas
- Instituto Colombiano de Antropologia e Historia, ICANH, Bogota
- Graph'it Studio, Warsaw, Poland
- United States Geological Survey, Reston, Virginia

In addition:
- Underground Mapping Services took their 3rd multichannel license
- ScanPlus expanded their single channel license to include multichannel
- Cemetery Coordinator, Oklahoma ordered a 2nd license.

GPRSIM Software licenses were delivered to:

- Ayed Eid Al Osaimi Geotechnic Co., Saudi Arabia
- Busan Metropolitan City, Korea
- Chien Hsin University of Science and Technology, Taiwan
- Dept of Mining and Minerals Engineering, Virginia Tech
- Roads and Maritime Services, New South Wales Government

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We are happy to announce that Laurel Geophysical Instruments in China renewed their exclusive marketing of GPR-SLICE in China and Hong Kong with a pre-order of 7 GPR-SLICE+GPRSIM licenses for 2018 with plans to add a minimum of 5 new subscriptions each year.

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We are also excited that Mala GeoScience is now independently marketing and providing software support for GPR-SLICE globally and has already delivered 4 new subscribers since this recent agreement was launched.

Software Updates

Among the most important new options or requested improvements added to GPR-SLICE v7.0 Software are:

- N segment interpolations of adjacent radargrams
- Georeferencing a local profile information file
- Horizon detection criterion
- Auto estimation of velocities from hyperbola regression fitting and the introduction of velocity and dielectric grid maps
- Conversion of user drawn line functions to random radargram cuts in the in OpenGL Volume Draw and OpenGL XYZ-2D Draw menus
- 3D object drawing on GPS radargrams in OpenGL
- Increased speed of graphic displays for 2D menus

N segment interpolations of adjacent radargrams

A new option was added to the Analytics menu under Filter to allow the user to make N interpolations between adjacent radargrams in a survey (Figure 1). The adjacent radargrams in the info file should have the same number of scans currently. If adjacent radargrams do not have identical scan lengths, then one can use the Resample option in the Slice menu to insure that the total number of scans between markers are identical. The interpolated radargrams will be named into the same folder that is highlighted and appended with the naming convention 1-, 2- … N-. A new information file will be written with the ending identifier info-N.dat.

The new option can also be applied to GPS/Vector surveys and the navigation files between the adjacent radargrams will also be linearly interpolated including vector columns in the *.*gps nav files. The new option can be convenient for vector surveys with identical line lengths but with insufficient areal coverage. One example is for radial tunnel images. In an example (Figure 2), 20 initial radargrams at 0.5 meters were interpolated 10 times to make higher density coverage. Interpolated radargrams a 5cm intervals were generated. Using the Direct Vector to 3D volume menu under the Radar pulldown menu, a solid 3D volume can be generated without the need for further cell interpolation needed.
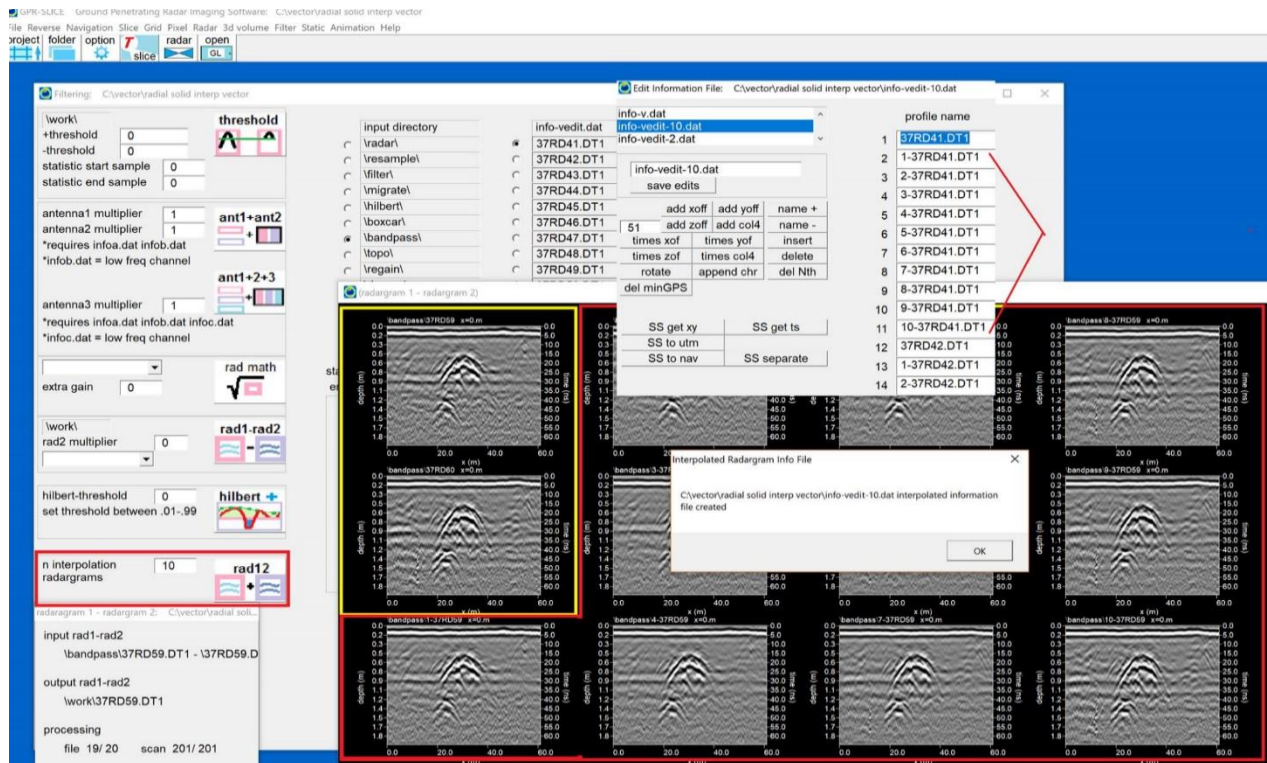
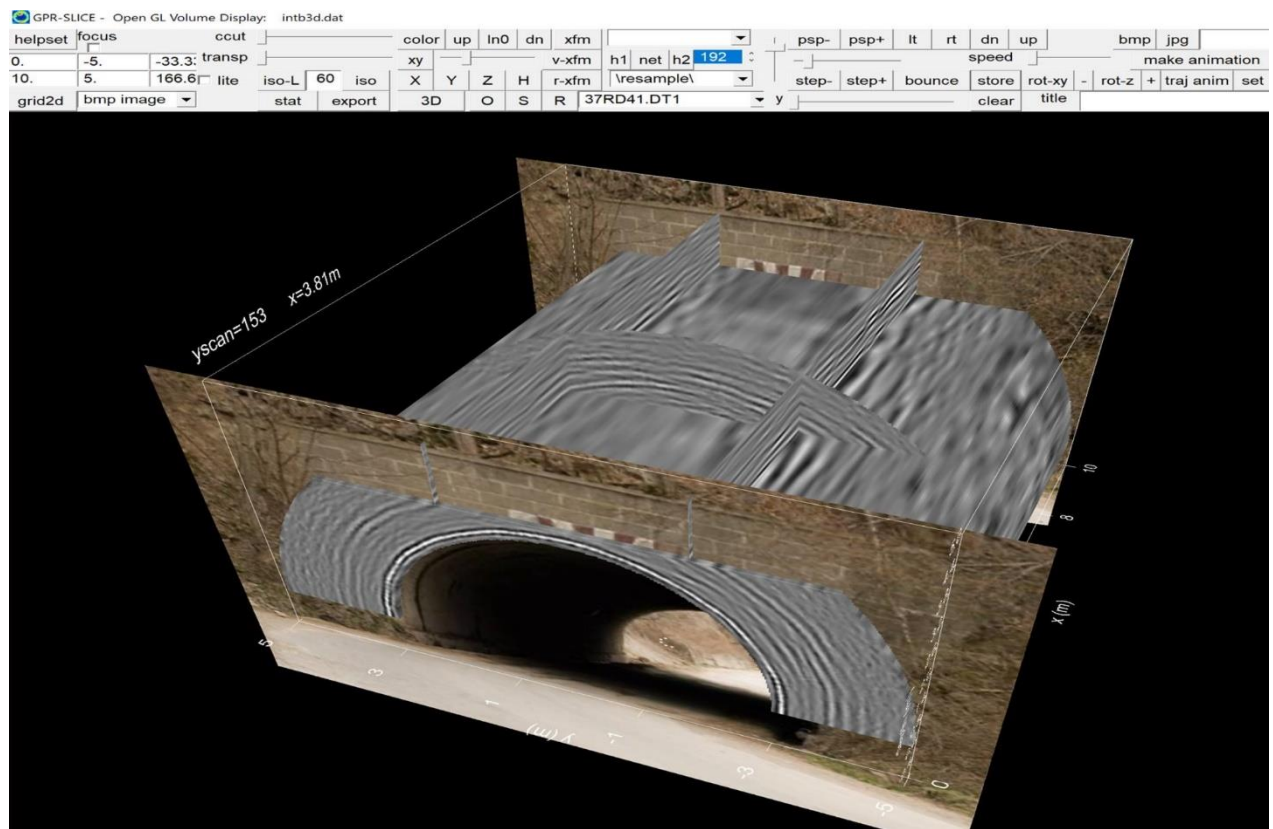Figure 1. N segment profile interpolation under Filter Analytics menu.

Figure 2. Example of a solid tunnel image made with interpolated radargrams

Georeferencing the Survey Information File

Many of our software users survey sites in local coordinates and then convert the imagery to georeferenced ones. Typically, the user will generate time slices and then use the 4 corner settings in the Pixel Map menu to generate Google Earth or ArcGIS exports. Another older method that exists in the Grid menu is for the user to rotate and translate a set of time slices into georeferenced time slices. These georeferenced time slices can then be used to export in the Pixel Map menu and can be used to generate a 3D volume where Google Earth bitmaps can be overlaid in the menu. One issue with these exports are that the radargrams defined in the information file are still in local coordinates and can not be displayed along with the georeferenced imagery in OpenGL.
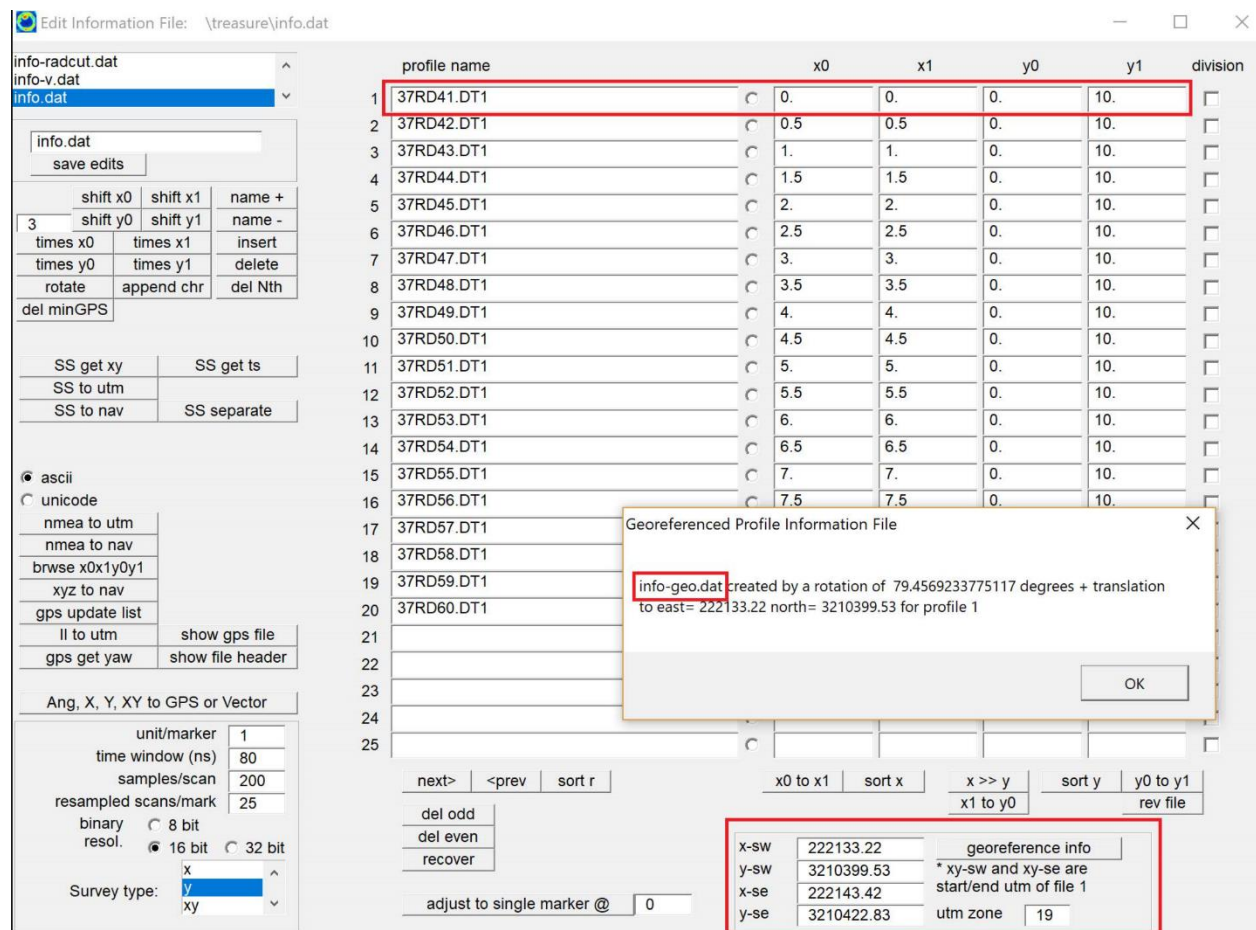

Figure 3. Setting of the xy UTM start/end points of the first radargram in the info.dat file and clicking the Georeference Info button will generate 2 additional info-geo.dat and info-geogps.dat files.

A new option to georeference the information file from the beginning will make all the imagery georeferenced and synced. The new option also makes it easier to generate the georeferenced info.dat file. In the Edit Info File menu the user needs to simply set the eastings/northings of the start and end points of the first profile listed along with the UTM zone number (Fig 3). Clicking the Georeference Info button, the software will calculate the rotation angles and the necessary translation values and apply to all the profiles in the info.dat file.

The new info-geo.dat file will be written as an "ang" survey definition in UTM coordinates (Fig 4). In addition, a third information file called info-geogps.dat is also automatically generated (Fig 5). This information will convert the info-geo.dat UTM file into an artificial GPS formatted survey. The advantages of processing the survey as a GPS formatted survey is that radargram displays in the Radar 2D menu will have 3 tiered labels with eastings/northings/integrated range. Horizon mapping also will require this format as native "ang" surveys need to be converted in any event before these menus can be implemented.
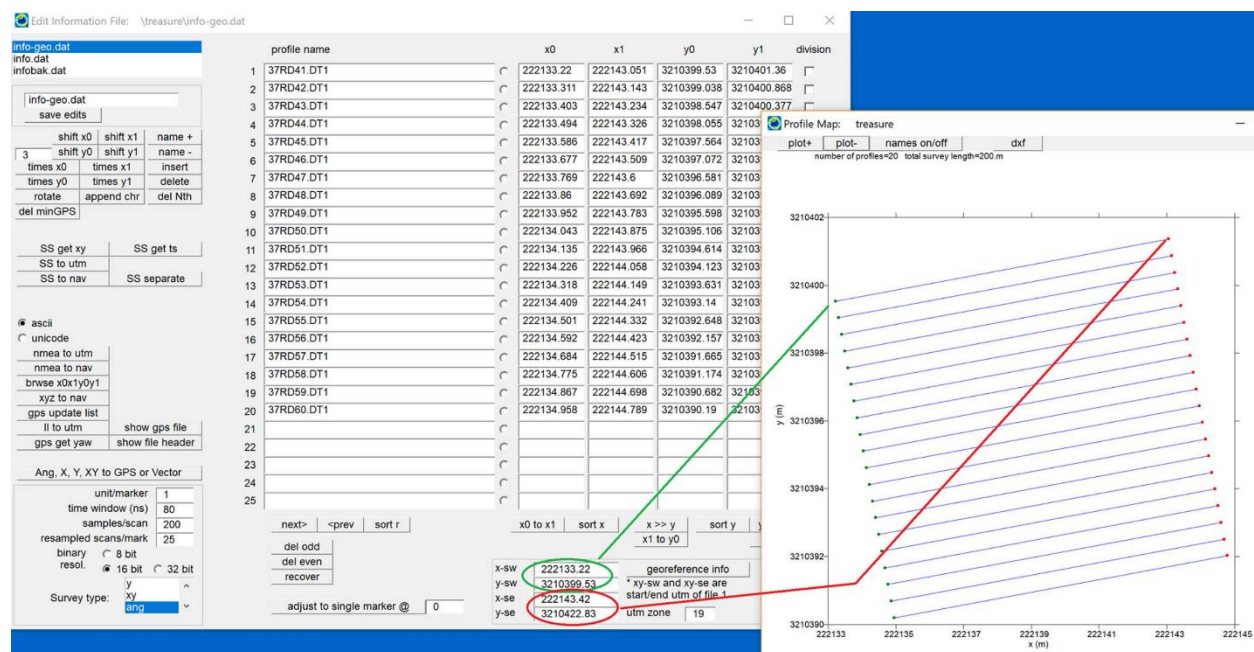

Figure 4. The info-geo.dat file shows the converted UTM information file. Although this intermediate georeferenced information is created, we recommend that the info-geogps.dat file be used and that the survey be processed as though the site were surveyed as an "artificial" gps survey.
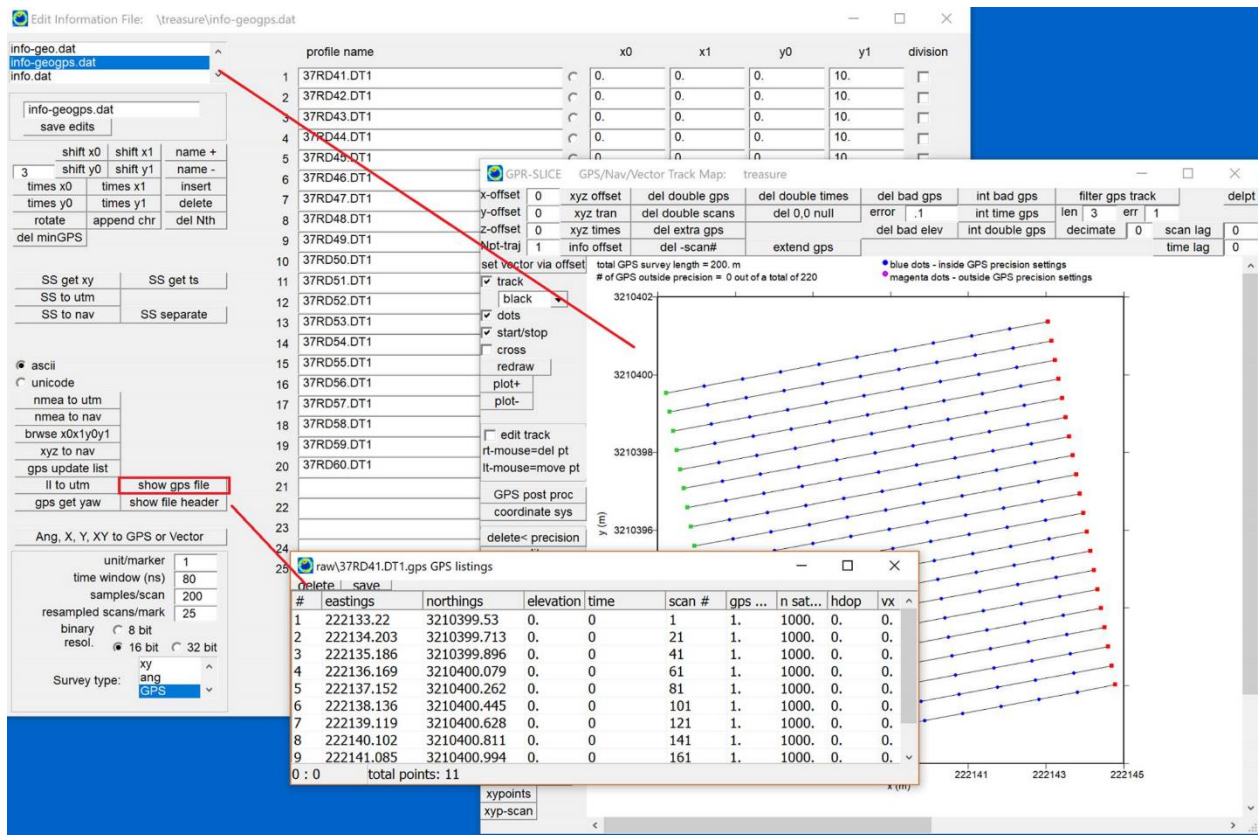
Figure 5. An example of th info-geogps.dat file showing the converted and georeferenced information file.

Horizon detection criterion

Automatic detection of visible horizons can be challenging. The auto detection looks at the strongest reflector over a given sample interval (Fig 6). In the example shown, horizon 2 is adequately detected, but horizon 1, because it is weaker and the horizon is quite variable in time is not continuously detected.

To improve the detection where a deeper horizon has a much stronger reflection signature then a shallower horizon, a new horizon criterion option was implemented (Fig 6). The criterion tells the search engine to look a certain number of samples above the detected horizon N to start the horizon auto detection for horizon (N-1). With this new option, horizon #1 can be adequately detected automatically.

The example shown is a GPS/GPR profile recorded from a helicopter with a dual frequency 500/1000 MHz Sensors and Software antenna in search for ice thickness (courtesy of Hugo Drouin). In this data, the top ice reflection (horizon

1) is overall much weaker than the ice bottom reflection (horizon 2) which has a contact with water.

The new criterion option can also be used to search for a horizon below a detected horizon. In this case, the number of samples below the detected horizon (N) would be set and the horizon number in the main menu slot would be set to N+1.

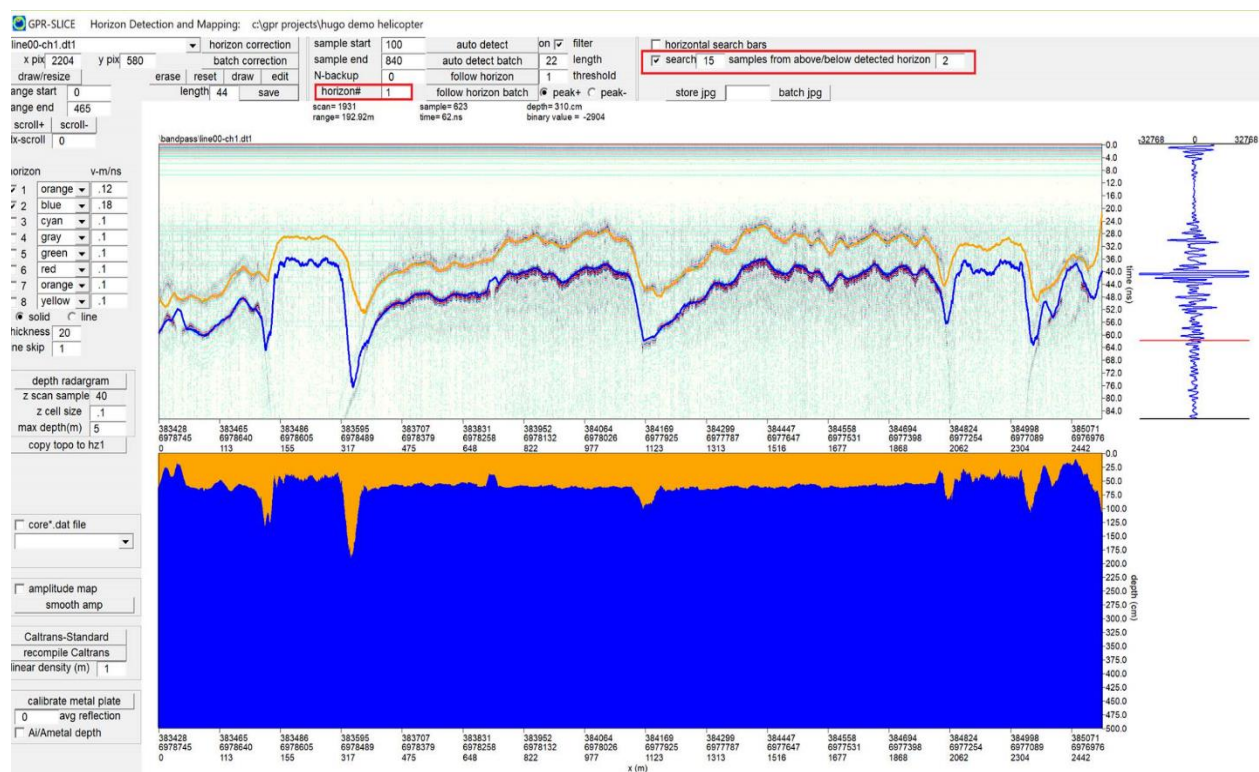The auto horizon detection and mapping menu is active in all GPR-SLICE licenses.

Figure 6. Example of the weaker horizon 1 assist – detected by using a search criterion in which the upper horizon #1 is found from looking 15 samples above horizon #2.

Auto estimation of velocities from hyperbola regression fitting and the introduction of velocity and dielectric grid maps

A new option to estimate the velocity of auto-detected hyperbola in the Search Hyperbola menu is now available for GPR-SLICE Bridgedeck licenses (Figure 7). To launch this option, the user highlights the "velocity search"
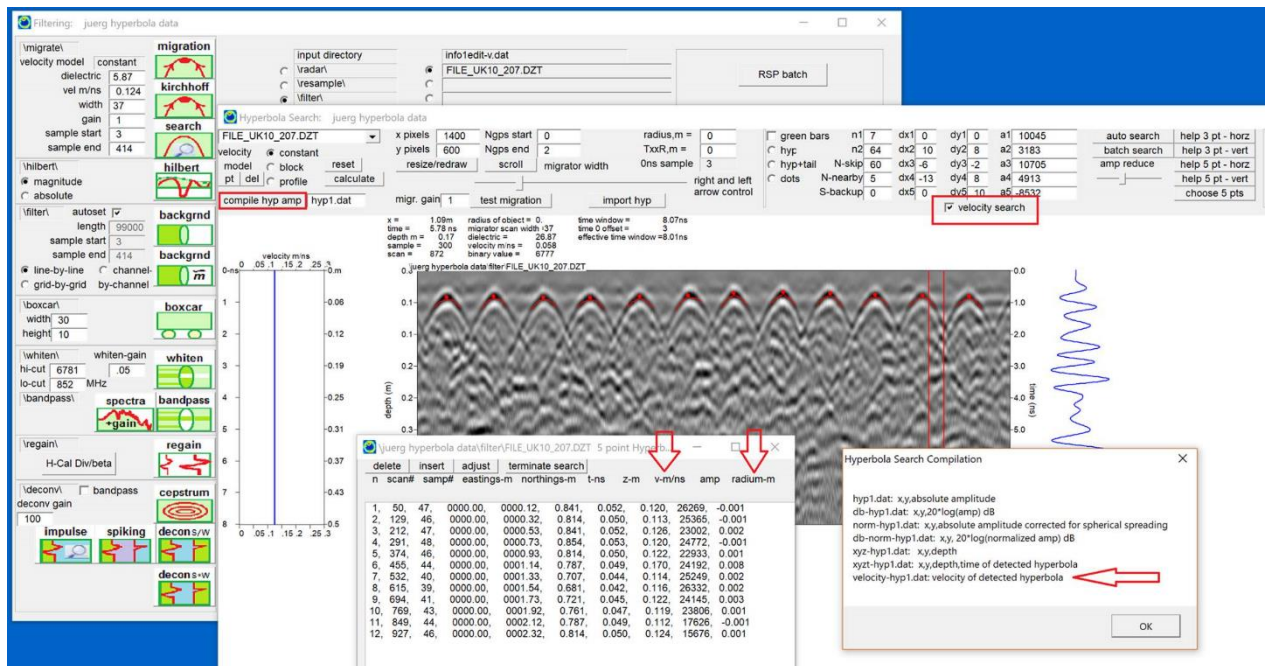
Figure 7. Option for Bridgedeck license do not get velocity information from regression analysis on hyperbola fitting on auto detection operations.

checkbox. The algorithm will detect the peak response of the hyperbola and using the identical phase on both sides hyperbola. The detected points are then used in a least squares regression analysis to give the best velocity fit to the hyperbola. A paper describing the regression analysis is given in "Utility Mapping with Ground Penetrating Radar: An Innovative Approach" Bello. Y. Idia and Md. N. Kamarudin. It is recommended that the user should first find the best auto-detection of the hyperbolas before clicking on the velocity search checkbox.

The regression will give the best fit velocity of each hyperbola. The points that were detected along the hyperbola are also plotted. Some variations and hyperbola responses that are not ideal can sometimes be seen, and those velocities could be suspect. The analysis also provides a very coarse method to estimate the radius of the object. This radius detection analysis, although included, should be cautiously used and the accuracy shows some wide swings as well as some slight negative radii which are not valid of course. The velocities, however, when compared with user matched hyperbolas do closely align with the estimated regression velocities!

With the new velocity column outputted in the Hyperbola Compilation button, the velocity over the xy grid of the site can now be generated (Figure 8a).   This velocity map can be used as another method to assist in estimating the deterioration of bridgedecks and other infrastructure features that are lined

with rebar or other cylindrical supports. From the velocity maps one might interpret areas with higher velocity as perhaps rebar locations where the concrete has better integrity. However, some areas where complete delamination, or areas with significant porous regions adjacent to the rebars, the air spaces might give an overall faster velocity signature. Whichever reality may exist at the site, comparison with coring, one could then extend that information based on the new velocity areal maps of site.

Using the expression that v=c/sqr(dielectric) dielectric areal maps can also be generated from the new regression analysis option (Figure 8b).
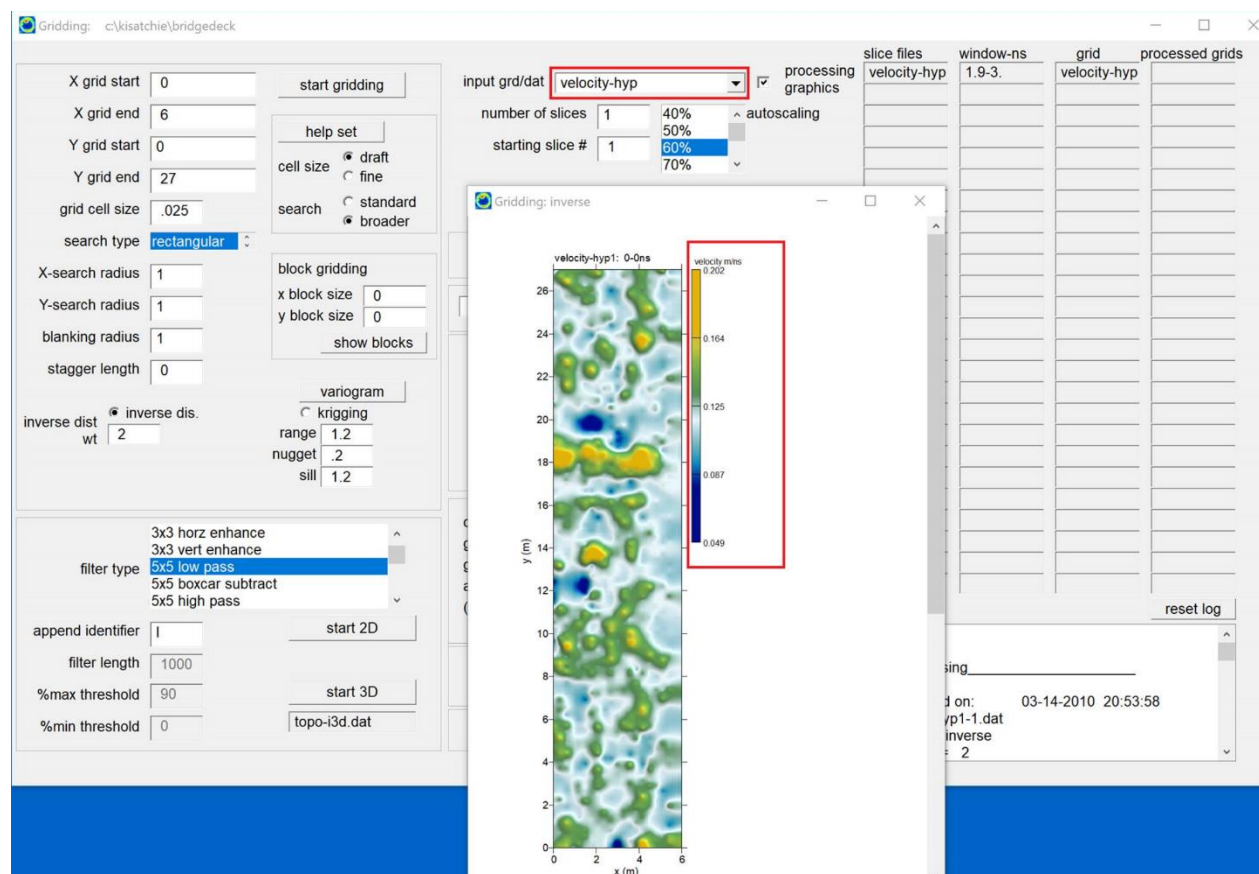
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Figure 8a. Gridding/display of the new velocity-hyp file generated from regression analysis and compilation of hyperbola information.
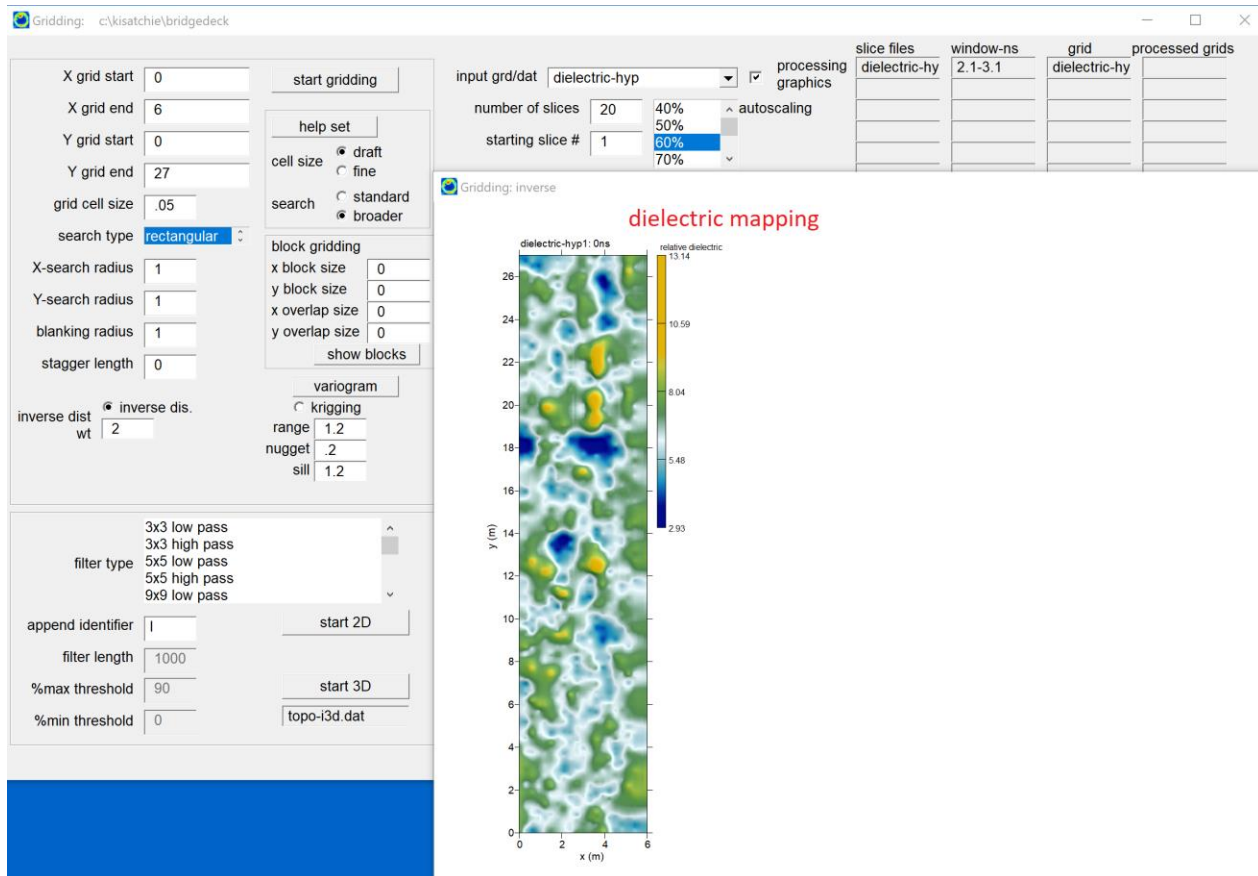
Figure 8b. Gridding/display of the new dielectric-hyp file generated from regression analysiss and compilation of the hyperbola information.

Conversion of user drawn line functions to random radargram cuts in the in OpenGL Volume Draw and OpenGL XYZ-2D Draw menus

A new function to make vertical cuts in the OpenGL menus from user drawn line functions was added to the OpenGL Volume Draw and OpenGL XYZ-2D Draw menus (Figure 9). What this feature allows the user to do is draw as many line functions with as many points that they want, then clicking the (Figure 9), those line functions will be displayed in OpenGL (Figure 10). The radar cuts are actually written as separate radargrams in the \radar\ folder and with the designated information file called info-radcut.dat (Figure 11). Even, if the volume is a regular xy survey, because the user can draw a random track line function, the radar cuts are written with GPS format and have those associated navigation files made as well. The user can open all the radar cuts in the OpenGL XYZ-2D menu and control the cursors in the Zscan, Xscan and Yscan displays by moving up and down and over the drawn multi-radar display. This feature might be best for those that use dual monitors to get the full displays but it is easily doable with single monitors as well. An real example

for use in showing perpendicular cuts across utilities from a multichannel survey is shown in Fig 12.

The impetus for this new feature was recommended by Jimmy Adcock at Mala Guideline Geo. Jimmy mentioned that a lot of multichannel users will often want to look at individual cuts in the volume data so that radar profiles are perpendicular to utility features. Utility surveyors will often export these perpendicular radar cuts and place in reports. With this new feature, one can create radargrams in any orientation and perpendicular to features at the site, even though the original radar swaths were not perpendicular but were even parallel to the utility features of interest! An example of this feature made from an IDS Stream dataset is shown in screen shot 4 where utilities are parallel to the lines and some are at an angle to the radar tracks.

Note: before clicking the Rad-Cut button you should place the active directory as the \radar\ so that the error message that the radar cut profiles are not found can be avoided.
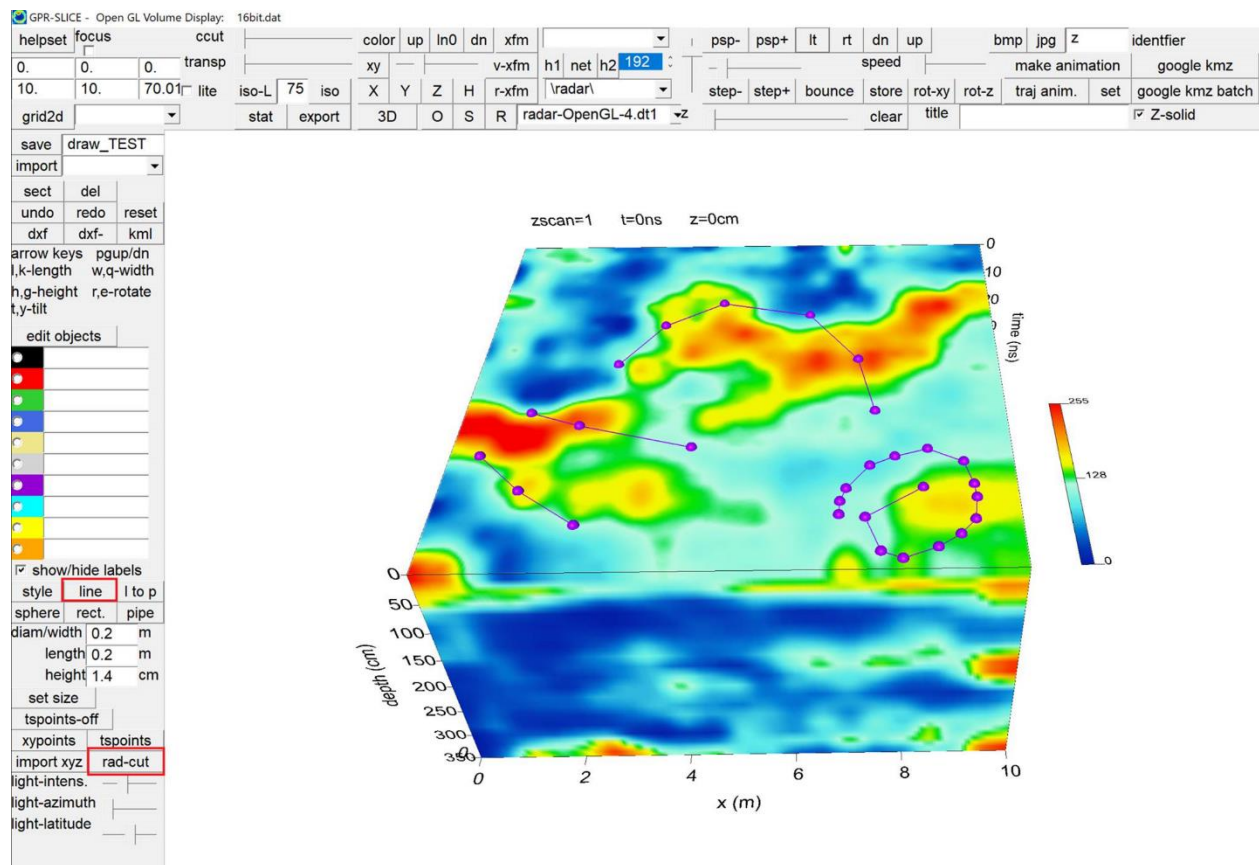

Figure 9. Example of the line function used to define customized radar-cuts and new radargrams in OpenGL Volume Draw menu.
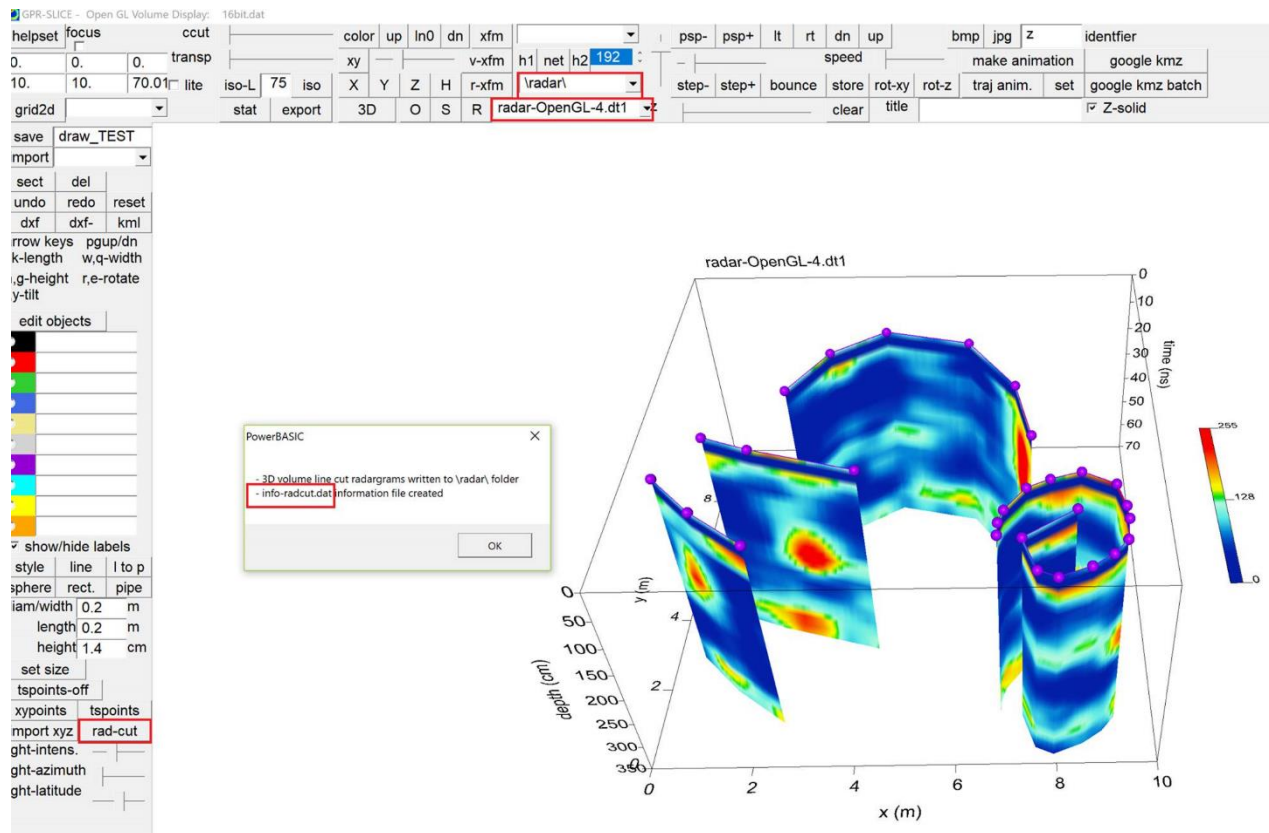
Figure 10. Display of custom radar cuts/profiles using the Radar-cut button.
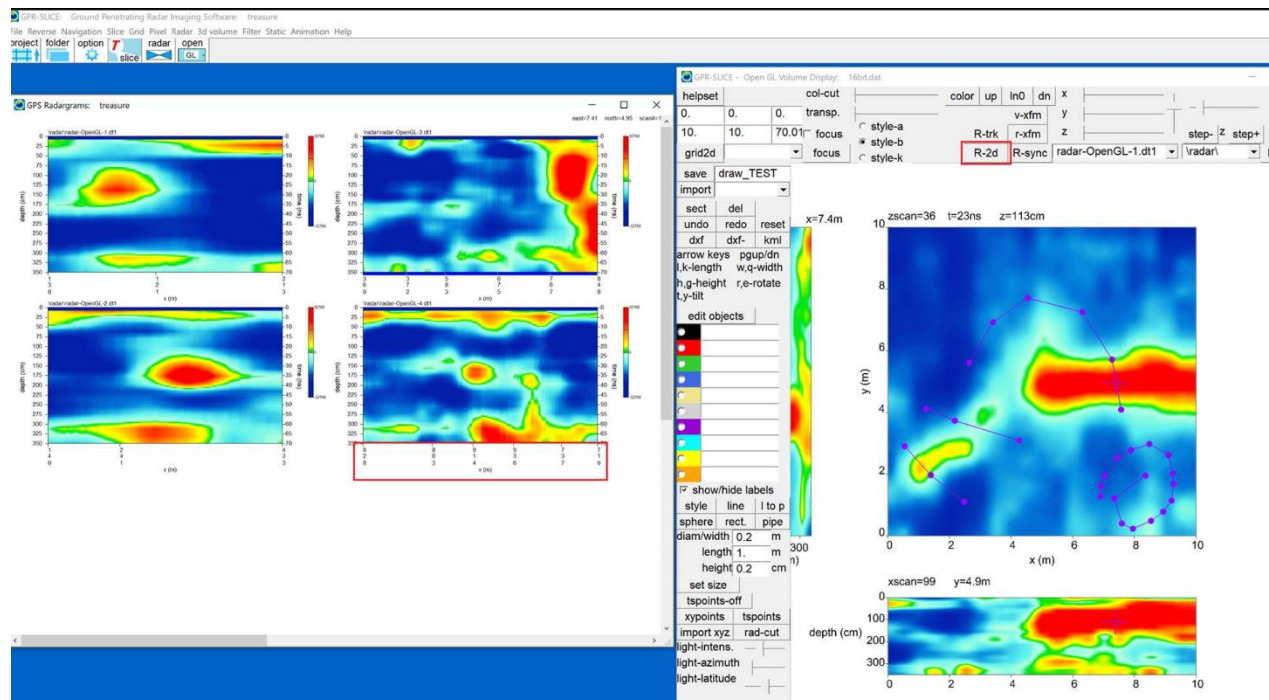

Figure 11. Display of the customized radar profiles generated from Rad-Cut line functions and with application to the OpenGL XYZ 2D menu.
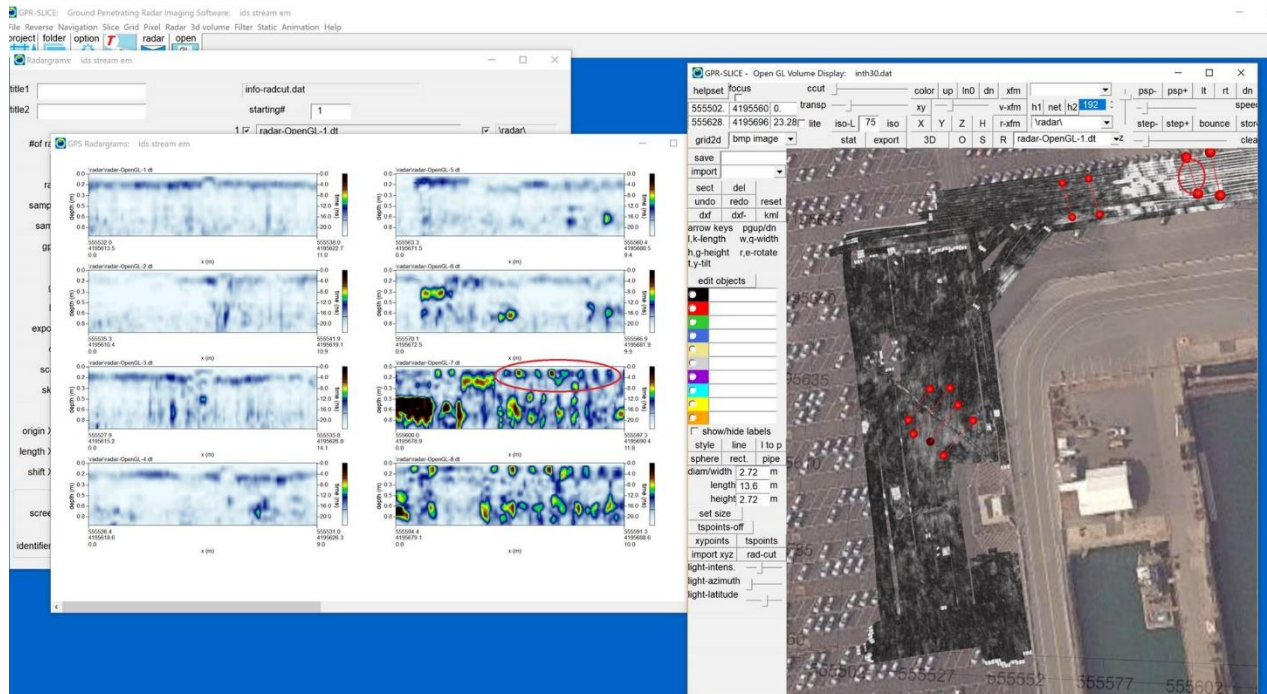
Figure 12. Example of customized radar cuts made from a hi-resolution multichannel dataset. Radar cuts made from drawn line functions in OpenGL Volume Draw are done normal to observed utilities see in the Zscan imagery.

3D object drawing on GPS radargrams in OpenGL

Drawing on x or y radargrams has been available in OpenGL Volume Draw menu for more than 5 years, however the ability to draw in 3D on GPS radargrams was not available. With a new drawing capability, this limitation has been removed! Clicking the sphere or line object, the user can place these objects anywhere on the variable track of the GPS radargrams (Figure 13). The x+/x- position of the mouse will control the horizontal position on the radargram and the y+/y- mouse position will control the depth position. A 3D cursor is also provided. If partial hiding of the 3D cursor occurs since it is masked behind portions of the variable track radargram, a small amount of transparency can be set with the slider bar before rendering the radargram to the screen (screen shot 2). This will provide viewing all the cursor axes that might get masked behind the radargram. The line width can also be adjusted to better visualize the cursor during drawing if needed (Figure 13).
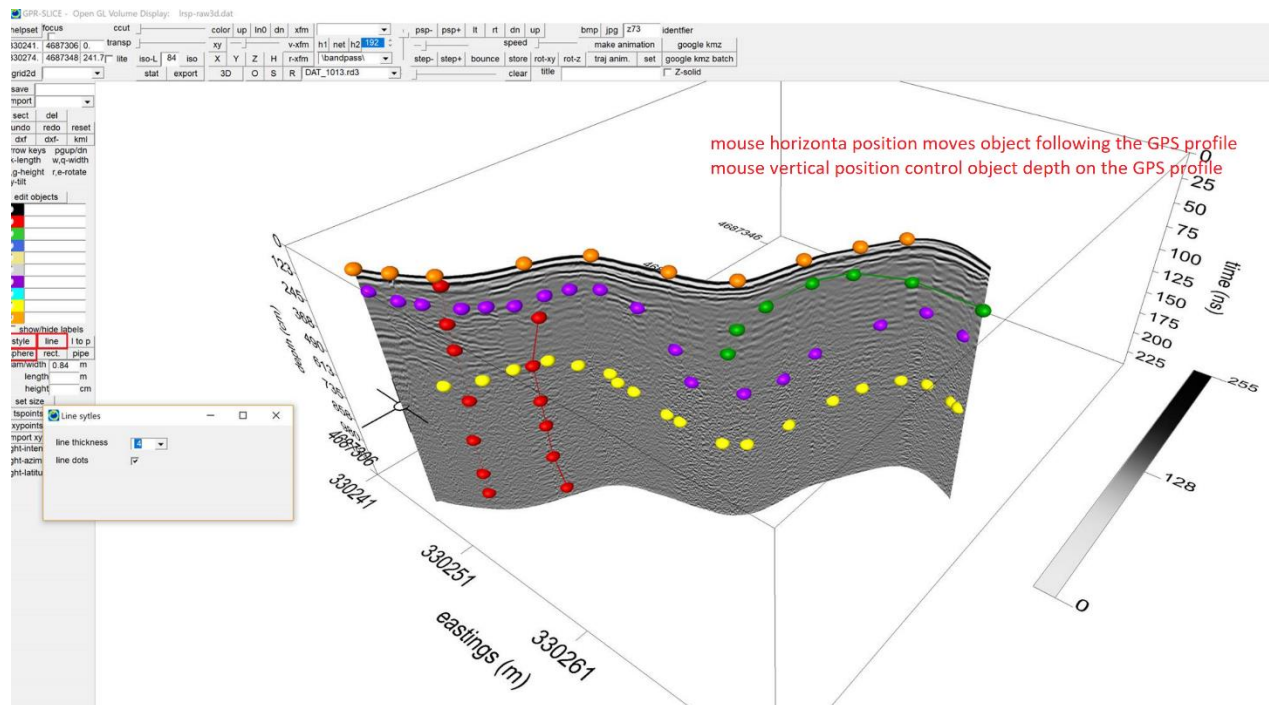
Figure 13. Option in OpenGL Volume Draw menu to place objects on a variable track GPS radargram.

Increased speed of graphic display for 2D menus

The Radar 2D menu and the Pixel Map menu were enhanced for improving the rendering speed of all graphics! To engage this new processing option the Optimize Speed radio button can be clicked on (Figure 14). The Optimize Resolution radio button is the standard look and will take the normal time for rendering. For most data, one will not notice any graphical differences between the comparisons of output to the screen. In the case when very coarse resolution data are being stretched more than over 4 or 5 times its native size, then one might see some slight pixilation with the new speed optimization compared to the resolution display. However, as most users are plotting data much less or near the native resolution, there will be absolutely no difference in graphical quality.

The new speed options are performed by generating bitmaps - rather than drawing each pixel to its location on the screen - and pasting those bitmaps to their proper location. Several tests performed on different size radargrams and time slices showed the lowest improvement at about 2.5 times faster and as high as 15 times faster for super long radargrams (35000 scans). Time

slices will also be drawn at much faster speeds with the new option engaged. For those with 4k screens you will notice the most improvement in graphical speed.
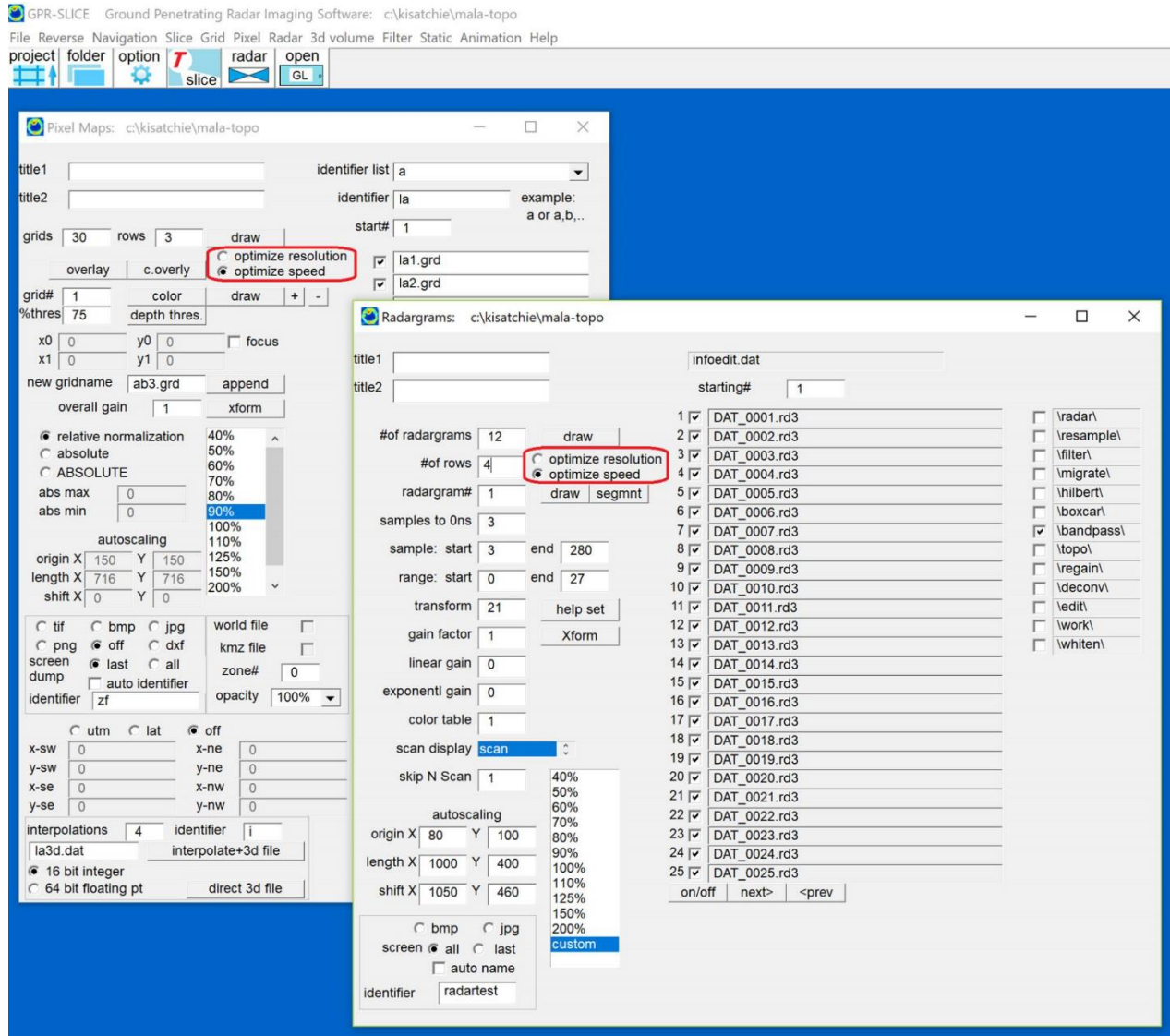

Figure 14. Location of the new optimize speed plotting option in the Radar 2D menu (and also available in the Pixel Map menu – not shown).

Other features and options added to GPR-SLICE include:

1) The user can set a default directory that will then be automatically propagated to create new projects without having to browse (Figure 15)
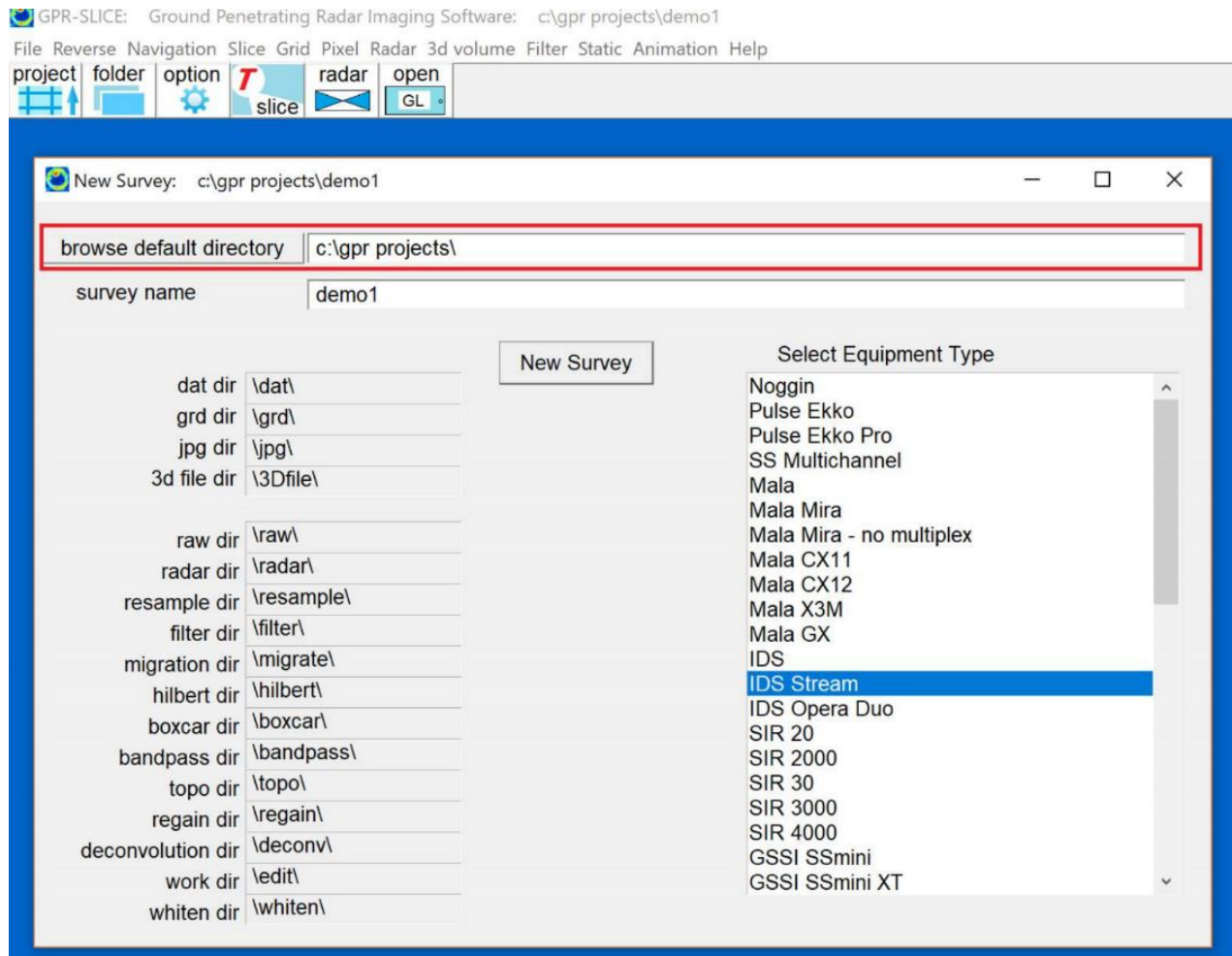

Figure 15. Option to set a mast or default directory under which to create a GPR-SLICE project. Note the default directory must be manually created first in Windows Explorer.

2) OpenGL Volume panning option using the middle mouse button or mousewheel held down to move the entire graphic window (Figure 16) which will assist those drawing utilities in 3D. Also requested was the XYZ scan information be written on the OpenGL menu so that it can always be seen even when close in panning is made.
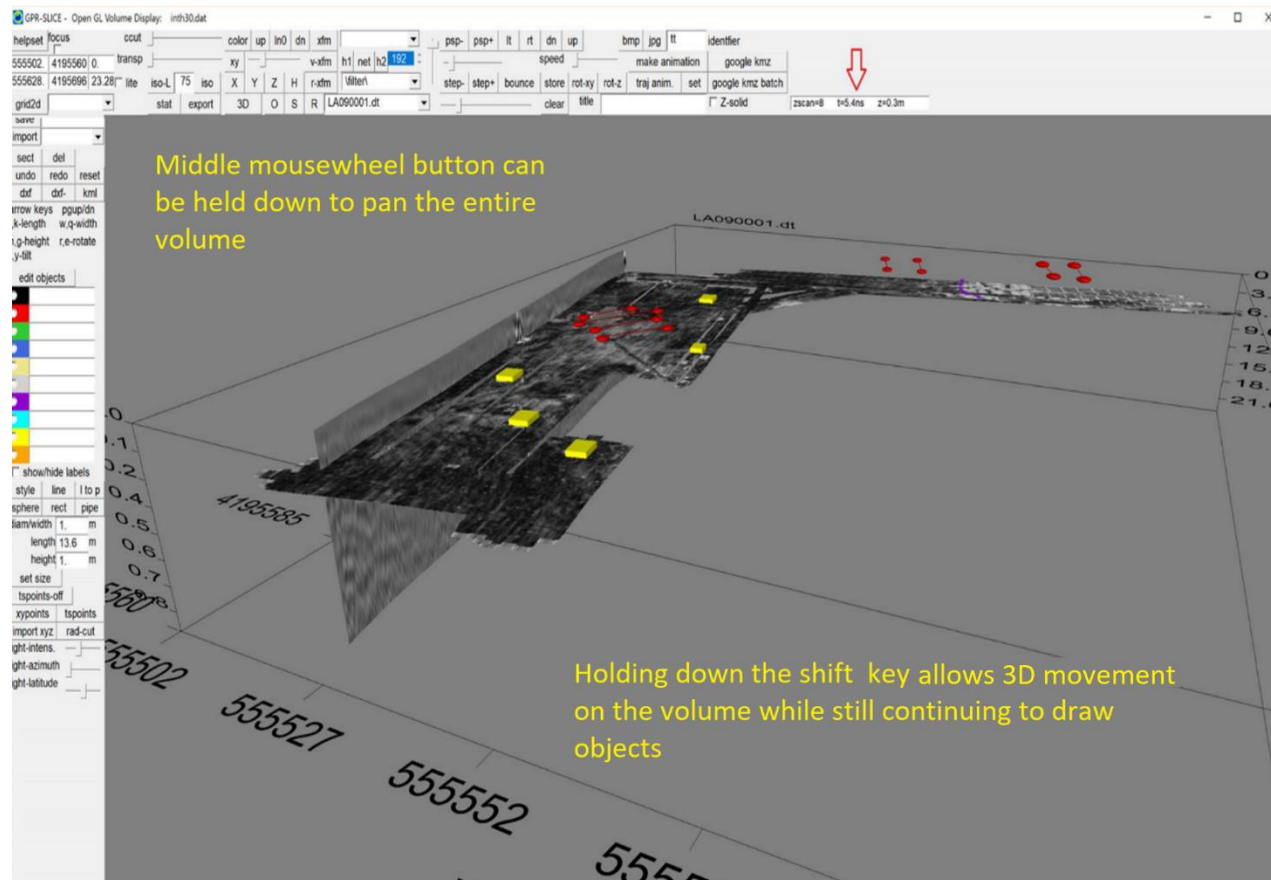

Figure 16. An option to pan an OpenGL Drawing menu by **holding down the mousewheel button** during drawing operations can be done real time. Also, **holding the shift button** allows 3D movement on the volume while drawing objects.

3) A new flag set in the Option menu will launch a floating pulse dialog graphic available during XYpoints operations in the Radar 2D menu (Figure 18). This dialog will automatically follow the mouse position to the next radargram and it will be displayed to the right of your current floating position. This will help those that chose the pulse information - rather than the scan color display - in anomaly picking in this menu.
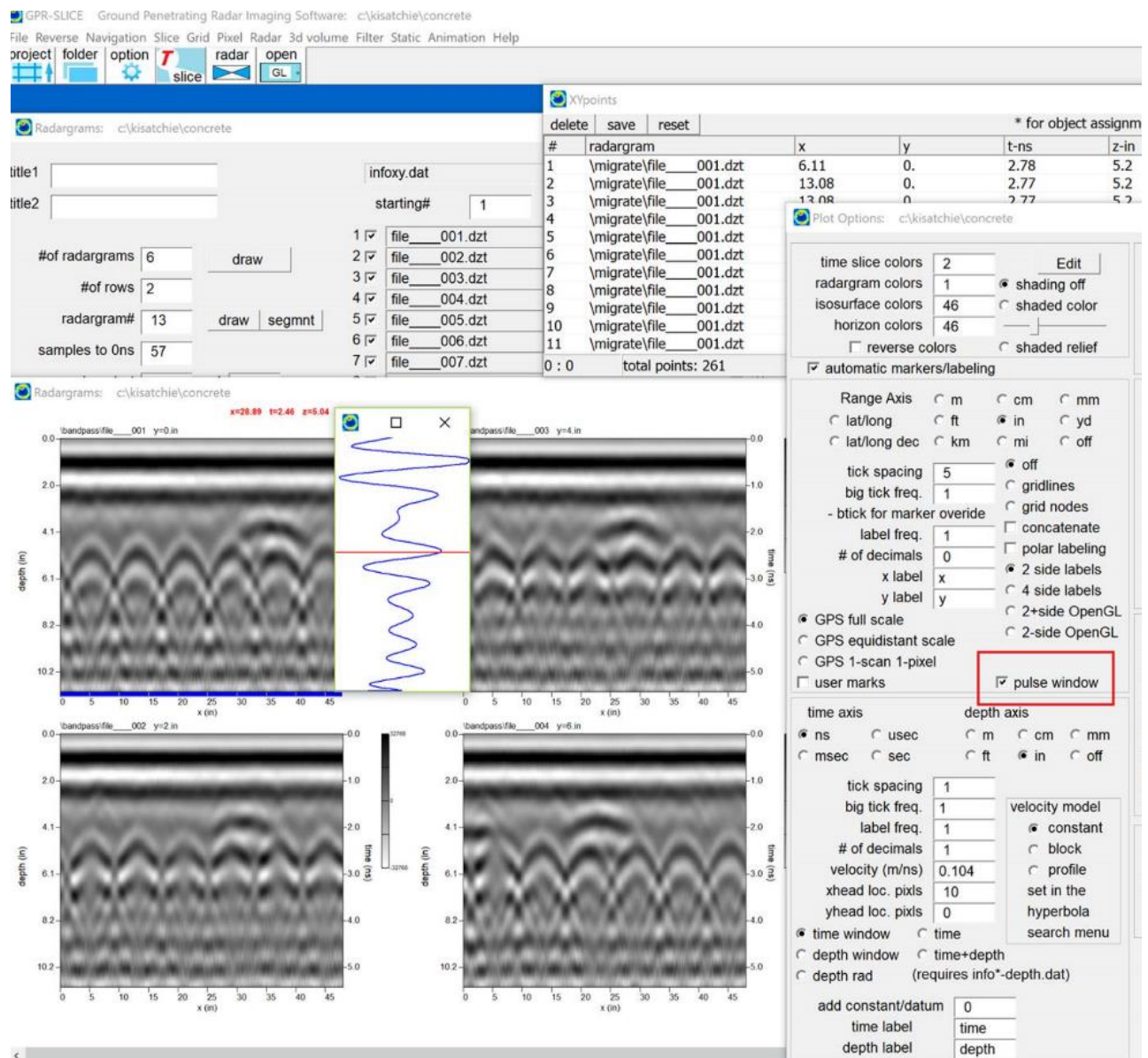

Figure 18. Location of the new switch for XYpoints to show a moving pulse dialog following the mouse scan position.

- Option to import the topography.dat file in elev. units other than meters
- 31x31 Low pass and high pass filters added to Grid menu
- Separate SIR 30 channels automatically generates separate infochannels-1-N.dat files
- Horizon auto detection parameters for each individual layer 1-8 recalled when changing the horizon number in the listbox
- Object_Export-Topo text file in OpenGL Volume Draw menu is available via the non-warping menu but with absolute elevation using a master topo1.grd file
- Option to auto generate georeferenced rotated/translated time slices in the Grid Menu via the 4 corner east/north or lat/long assignment in the Pixel Map menu
- Export text file in OpenGL Volume Warp + Draw menu will write a separate absolute elevation column in conjunction with reading a global topo1.grd master topo file
- OpenGL Volume Draw cursor sensitivity setting from 1-10 available in the Options menu (default=5)
- Grid block and XY overlap for topography topo1.grd file extended to allow OpenGL Topo Volume warping of grid blocks
- Block overlap option for x and y axes in parsing large multichannel volumes into segmented volumes
- Accelerator keys in OpenGL Volume Draw disengaged during non-drawing operations allowing lower case (accelerator key) letters to be inserted as object names
- Get Google Map bitmap option in OpenGL will automatically set depth of sitemap bitmap to 1.01*depth of the volume on initial placement
- Object-export.txt file with navigation in UTM and lat/long exported via the Edit Object menu in OpenGL Volume Draw
- Sensors and Software demultiplex option added to Edit Info File menu
- OpenGL object annotate font size added to Options menu
- Step rotation buttons about Z axis in OpenGL added
- Import of bpw ArcGIS world file in OpenGL BMP Overlay menu to automatically insert the SW, SE, NE and NW corners of the image
- Del Double GPS replaced with Del Double Loc so that any consecutive identical eastings/northings are removed
- DXF output will append the Save menu item identifier in front the export files for autocad allowing customized filenames
- New hotkeys in OpenGL Volume Draw menu using the rt/lt arrow keys to advance xyz scans or radargrams and the shift key held down to continue rotating the volume during draw commands
- All speed improvements on displays are engaged for batch radargram filtering and time slice grid create
- Improvement of mouse action in drawing objects on Zscan and XY profiles in OpenGL in the 4 quadrants

- Position information written to pulse dialog for XYpoints operations.
- File header display available for some manufacturers in the Edit Info File menu
- Option to hardwire antenna vector vx,vy,vz in the GPS Track menu via the x,y,z offset menu slots
- Direct vector radargrams to 3D binary volume compilation
- 3D cursor for drawing objects on GPS/XY radargrams in OpenGL Volume Draw menu
- CSV readable file csv-info.dat written on saving in the Edit File menu for opening with columns in Excel
- OpenGL Volume Draw text oriented to match line angles

New Recommended Processing Procedures

New recommended procedures for processing multichannel data and other single channel data where background filters are used. The order in which radargram signal processes can have an important effect on the quality of the data quality. Recent imagery generated by Dr. Gianluca Catanzariti using IDS Stream multichannel equipment clearly indicates that background filters should be applied prior to bandpass filtering (Figure 19). A good example of the difference in quality is shown in the screen shot below produced by Gianluca. The bottom time slice imagery shows much cleaner and clearer anomalies and has been processed with background prior to bandpass.

Our typical full processing scenario for multichannel equipment is now recommended to have background filtering applied prior to bandpass filtering:

1) conversion with:
   wobble on if the data have significant dc drift
   wobble off if the raw data already looked bandpassed
2) time 0 correction
3) background filtering
4) spectra+gain setting followed with bandpass
5) migration, deconvolution etc as needed
6) Hilbert transform

Some equipment already records raw data with bandpass filtering engaged in the control unit and others do not. For data that does not have bandpass applied one will see improved quality in the final radargrams with the new recommended procedure.
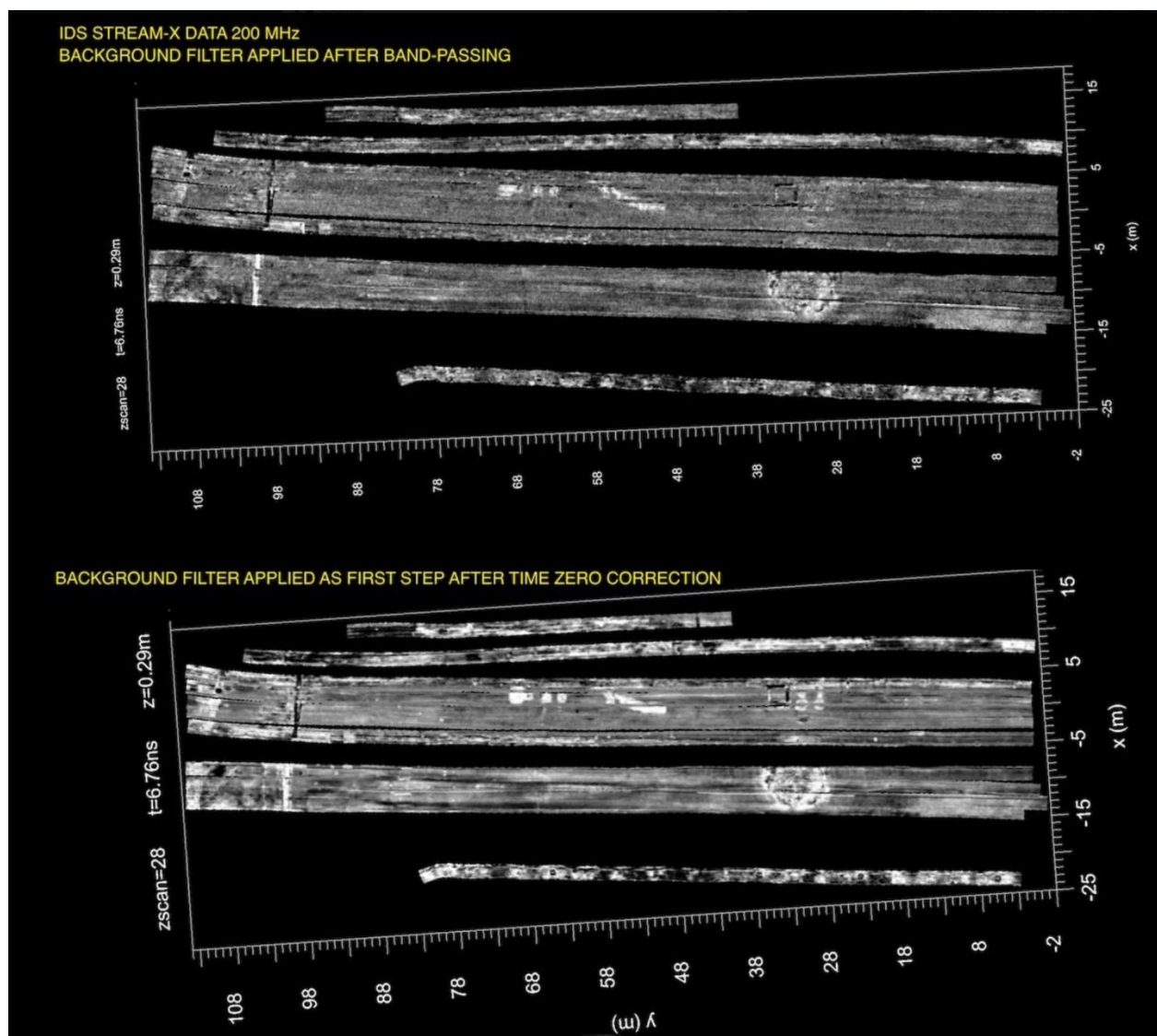
Figure 19. Comparison of multichannel processing with background filtering made after (top diagram) and before (bottom diagram) bandpass filtering. The bottom diagram shows improved signal-to-noise in the final imagery.

Facebook Forum

The Facebook Forum for GPR-SLICE has been actively used and is a useful resource for finding more in-depth answers and discussion on relevant GPRSLICE software topics. All the new options to GPR-SLICE were first introduced in Facebook and this newsletter just represents a catalogue of some of the important new features added. Additional user discussions and more in-depth explanations are available in the GPR-SLICE Facebook group. If you have not yet joined the GPR-SLICE Facebook page, I would encourage

you to do so at: https://www.facebook.com/groups/gpr.slice/   There are currently 702 active members in the GPR-SLICE FB group.

Events

A 2-day GPR-SLICE workshop was made at the Southeast Archaeological Center, National Park Service in Tallahassee Florida on July 20-21. A total of 18 archaeologists attended the event with several archaeologists from the Florida Bureau of Archaeological Research.

GPR-SLICE was exhibited at GPR 2018 in Rapperswill, Switzerland from June 18-21.   It was great to see a lot of old friends and colleagues.
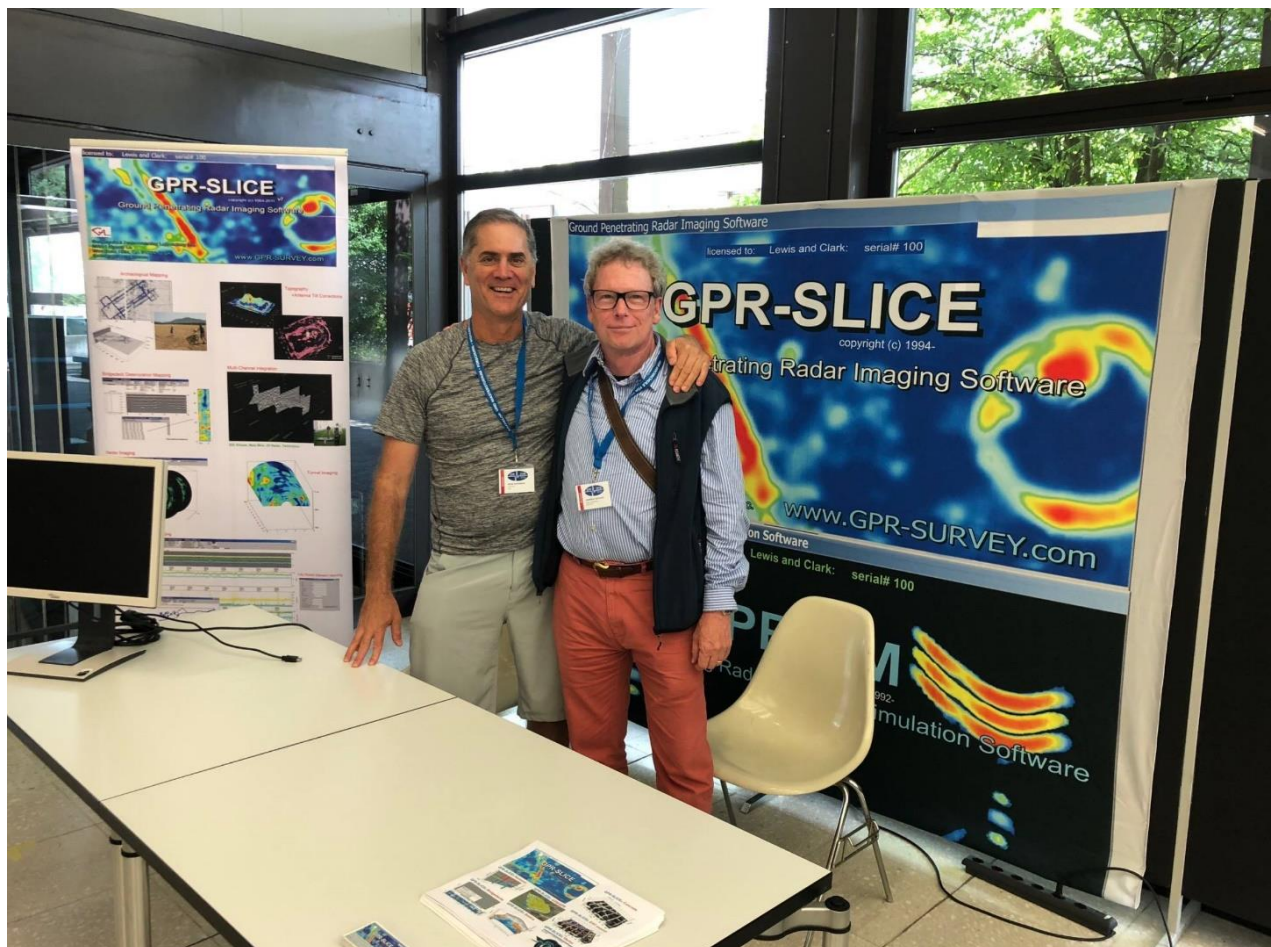
https://www.gpr2018.hsr.ch/index.php?id=15715&no_cache=1

Dean Goodman
GPR-SLICE Software