

Newsletter - September 2016

**GPR-SLICE** users,

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

- Sterling Geo, United Kingdom
- Geomecca, Korea
- Logan Simpson Inc., Tempe, Arizona
- Murphy Surveys Ltd, Cork, Ireland
- RADAR Geoservizi s.a.s., Torino, Italy
- United States Army Corps of Engineers, Sacramento, California
- DB International GmbH, Bremen, Germany
- GHD, Perth, Australia
- Oriental Institute, University of Chicago, Illinois
- Beobom, The Netherlands
- Geoprospect S.A. DE, C.V., Nuevo Leon, Mexico
- Round Rock Geophysics, Austin, Texas
- Virginia Institute of Marine Sciences, College of William and Mary
- Michalis Poultidis, Larisa, Greece
- Geophysical Survey LLC, Kennewick, Washington
- ScanPlus Locating Ltd, Sooke, BC, Canada
- Draper Laboratories, Cambridge, Massachusetts

- French National Institute for Preventive Archaeology - INRAP
- School of Science and Technology, University of Camerino, Italy
- All GPR LLC, Fountain Hills, Arizona
- Glen Dash Foundation for Archaeological Research
- National Geographic Society, Washington D.C.
- Environmental Programs, Dugway Proving Ground, US Military, Utah
- ATS International Inc., Christiansburg, Virginia
- Nordic Volcanology Center, Institute of Earth Sciences, University of Iceland
- Land and Marine Surveys, South Africa
- Sumet Yerbilimeri Ltd., Izmir, Turkey
- RealTime-Metrology, Houston, Texas
- ESG Infrastructure Services, United Kingdom
- National Park Service, Lowell, Massachusetts
- Geoplus Eng Co. Ltd., Korea
- Dept of Anthropology, Texas State University
- Kawasaki Geological Engineering Co., Ltd., Tokyo, Japan
- Center for Northeast Asian Studies, Tohoku University, Sendai, Japan
- Mitre, Bedford, Massachusetts
- Ground Radar, Toronto, Canada
- Geomaster Corporation, Quezon City, Philippines
- David Charles Nobes, New Zealand
- University of Southern Queensland
- EGS Asia Limited, Hong Kong
- Electronic and Telecommunications Research Institute, Korea
- Massachusetts Institute of Technology
- G. I. Engineering Co., Ltd, Korea
- Desert Research Institute, Nevada
- Finders University, Adelaide, Australia
- John Trust, UK

GPRSIM Software licenses were delivered to:

- Tongji University, Shanghai City, China
- Geomecca, Korea
- Tianjin Survey and Design Institute for Water Transport Engineering
- CCCC Shanghai San Hang Research Institute Co.,Ltd., China
- Draper Laboratory, Cambridge, MA
- Beijing Syndec Instrument Co., Ltd., China
- Geotechnical Korea Eng Co., Ltd.
- IDD France
- Electronic and Telecommunications Research Institute, Korea

## **Software Updates**

Among the most important or requested improvements added to GPR-SLICE V7.0 Software are:

- Vector 3D volume generation from 3D vector radargrams
- Vector imaging for rooms, walls and circular structures made simple with menus to automatically set the vector navigation files
- Auto storage of Google Maps in OpenGL Volume
- Combining multi-frequency antennas
- GPS multi-radargrams display options: a1) GPS full scale 2) GPS equidistant scale and 3) GPS 1-scan per 1-pixel
- GPS post processing from master.gps file

### **Vector 3D volume generation from 3D vector radargrams**

Finally, the union of vector radargrams is combined with vector volumes! This has been a long desire of mine to have any radargram in any orientation in space and to be able to generate a 3D volume from these projected radargrams. We have in the past provided simple features like tunnels, cylinders and topographic vector volumes. However, the generalized operations for any vector were not available. These are now explicitly available in GPR-SLICE!

The operations are to:

- 1) Generate vector navigation files in the software or import them from other sources such as yaw pitch roll sensors etc. The vectors can show the radargrams in any 3D spatial orientation. (An example of some radargrams made with a twist in 3D space is shown in Figure 1).
- 2) The slice/resample menu is run using the XYZA-Vector compilation (Figure 1) This will slice and bin the data, and then the vector position of that bin in 3D space will be written to a 3D file called XYZA-vector.dat. This file is 4 columns and has the xyz position along with the bin parameter which is usually the abs(amplitude) or squared (amplitude) average in the bin.
- 3) XYZA-vector.dat file is a 3D file and requires 3D interpolation. Using the Import 3D Geophysical Data menu, the file is imported and this initially creates a 3D binary file for viewing in OpenGL (Figure 2). This file will generally have a lot of empty 3D cells so some interpolation is usually required. The number of cells in the XY direction and the number of cells in the Z direction can be

set independently. After interpolation, the append identifier "int" is placed on the new gridded volume. The 3D interpolation currently has inverse distance gridding hardwired into the interpolation algorithm. After interpolation the Grid menu can be used to apply additional voxel smoothing to the volume if desired.

An example of a 3D volume made from vector radargrams having a 3D twist are shown (Figure 3). The new operations available for vector volume generation will allow the user for instance to show isosurfaces made on all the separate walls in a room and show those isosurfaces simultaneously in the same volume! Any visualization defined by the vector radargrams can now be interpolated in 3D to create a solid 3D volume of that vector space!

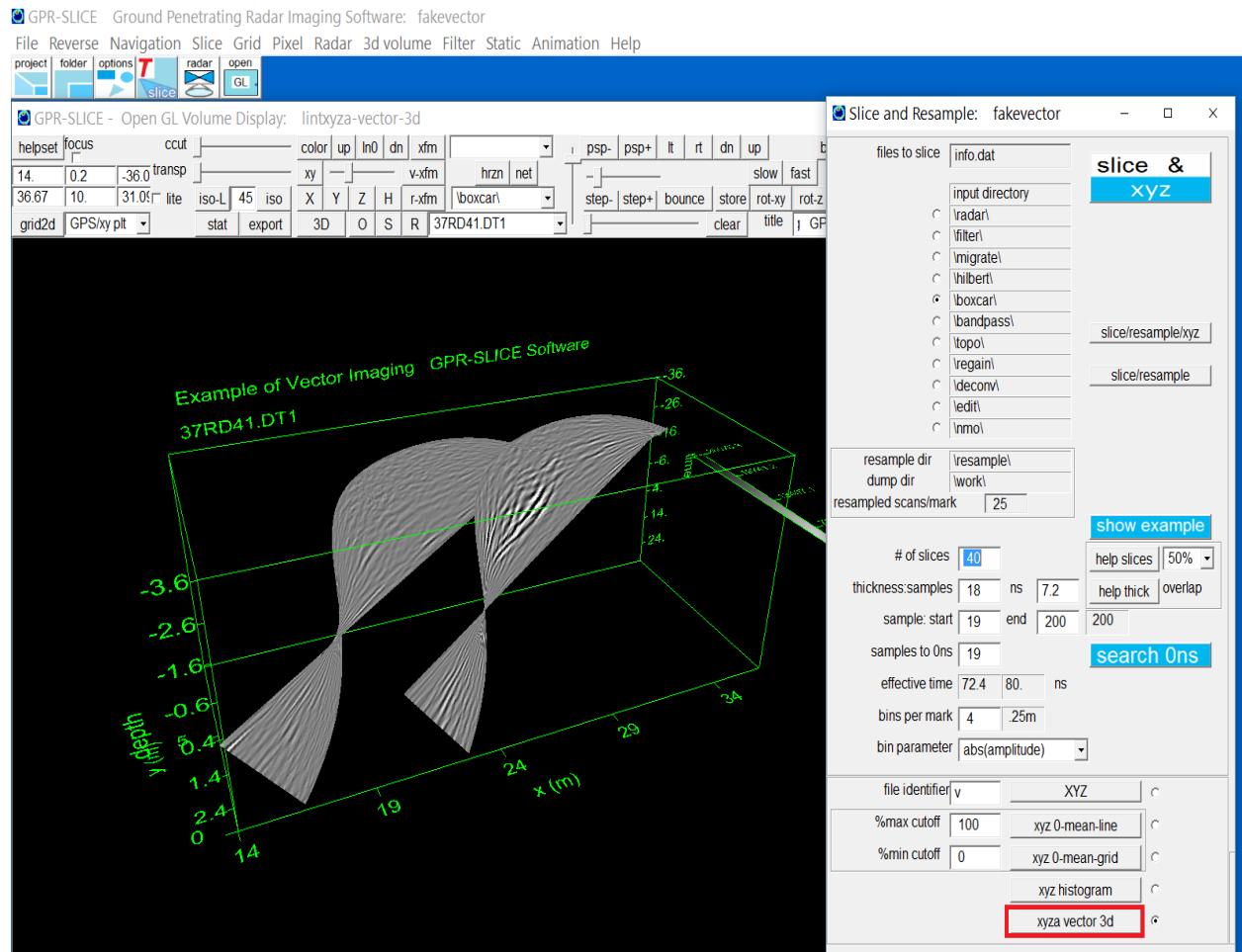


Figure 1. Image showing example vector radargram with a 3D twist. The slice 3D \dat\vector-xyza.dat file from the Slice/Resample menu are compiled using the XYZA vector 3D radio button.

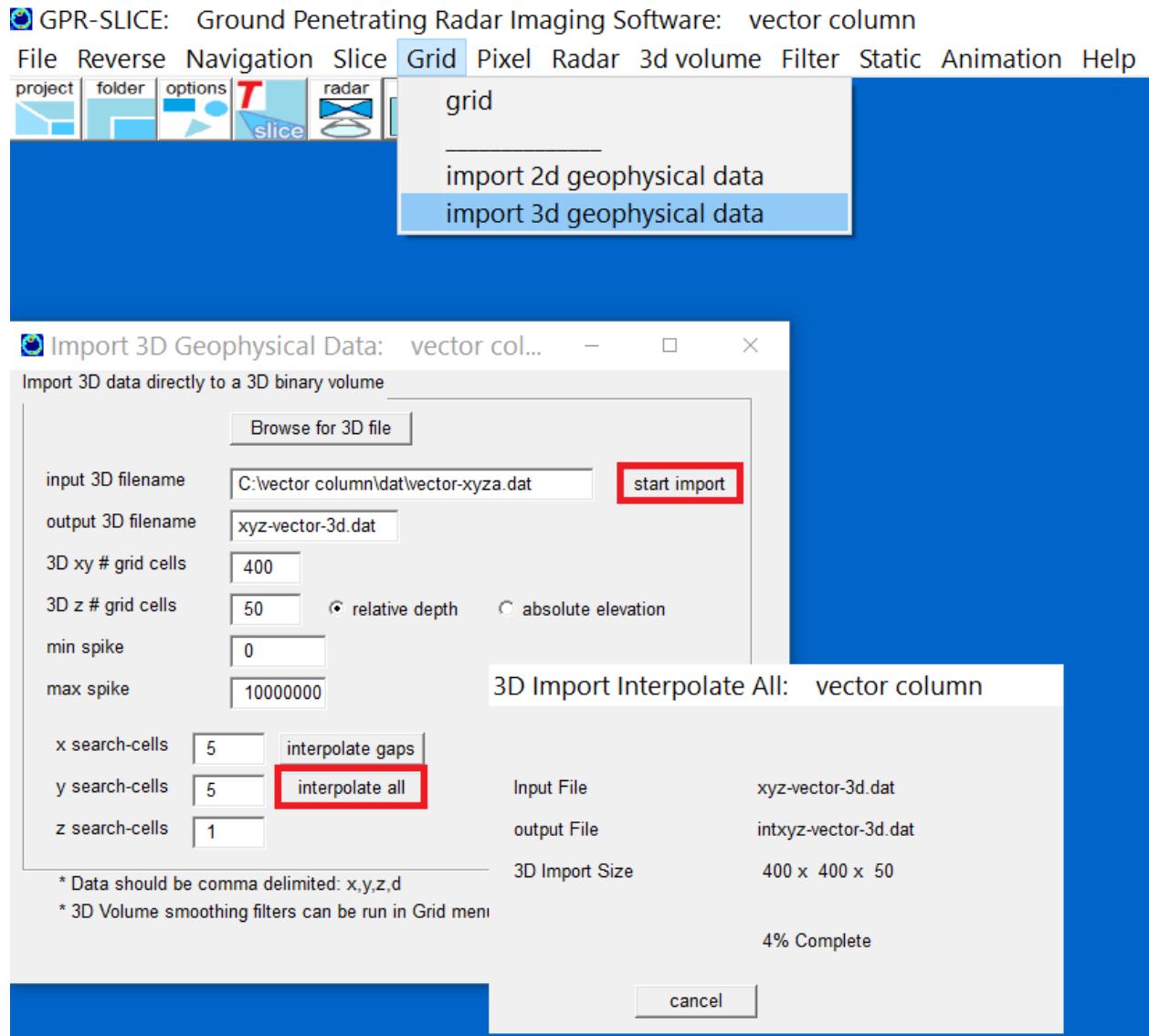


Figure 2. The compiled 3D vector file is imported directly into a 3D binary file and 3D gridding/interpolation are applied to the volume to generate a solid volume with desired xy and z grid cell densities.

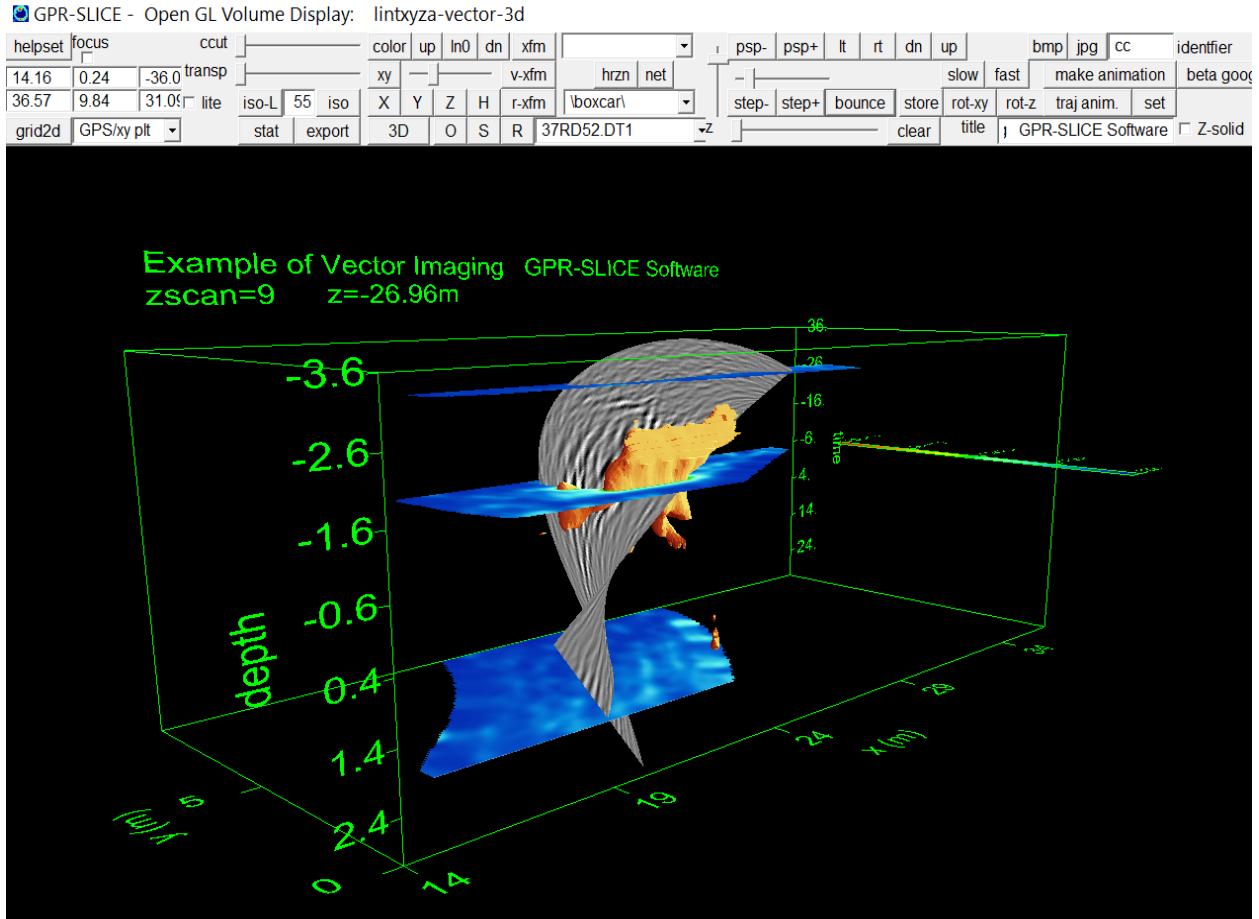


Figure 3. Example of a 3D gridded xyza-vector file displayed in OpenGL Volume with vector radargrams, 3D time slices and an isosurface.

## Vector Imaging for walls

Making surveys on walls or tanks has just gotten easier inside the software. A new import in the Create Info File menu called `vector_survey_information.dat` will import an 8 column file that has the radargram name, xstart, ystart, zstart, xend, yend, zend, and the angle description 0, 90, 180, 270. 180 signifies a profile that is made inside a room for instance, and will project the radargram going outward; and 0 would be outside the room and will project the radargram in the opposite direction. 90 and 270 degrees will project the radargram either upward or downward. For instance, doing surveys on a ceiling one would set the vector to 90. Note, the direction of the profile line can be at any angle. The import will compute the normal vector to the line set in the `vector_survey_information.dat` file and will adjust the vector navigation files automatically.

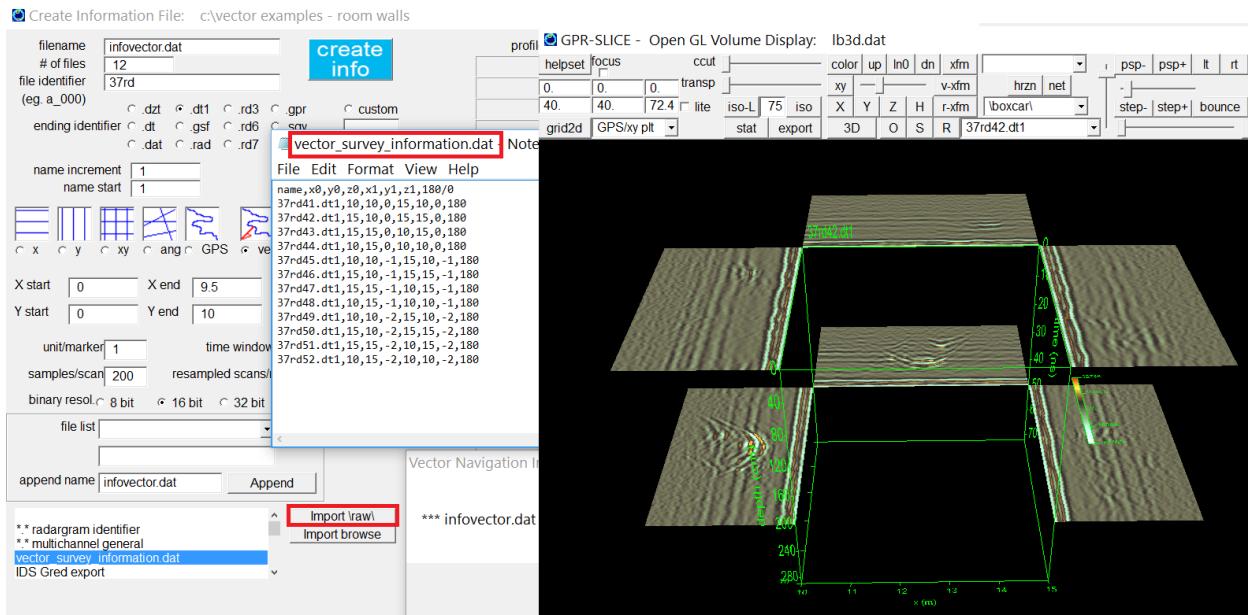


Figure 4. Vector imaging on walls is made easy with the new vector file import in the Create Info File menu.

## Vector Imaging for Circular Structures (e.g. tanks, columns etc)

A menu specifically designed for setting the vector on circular structures was also enhanced in GPR-SLICE. Shown in Figure 5 is the Vector Circular Survey menu. In this menu 5 settings are required: 1) the start angle 2) the end angle 3) the elevation 4) the radius 5) and the vector orientation. 4 vector orientations are available with settings 0 (pointing horizontally outward from the circle), 180 (pointing horizontally inward to the circle), 90 (vertical pointing vertically upward) and 270 (pointing vertically downward). The vector settings do not need any initial settings of the  $x_0$ ,  $x_1$ ,  $y_0$ ,  $y_1$  and these can all be set to 0 before beginning the vector creation. An example of the vector set for 2 radargrams collected on a tank for instance, shows a vertical circular radargram and a radial radargram, linked together at the top. There are quick buttons on the bottom on the menu to replicate all the settings for file 1 to all the files in the list, as well as help buttons to adjust the elevation of the radargram profile which is useful for setting radial profiles taken on a circular column for instance.

Once the vector radargrams are made and if they are sufficient in areal coverage and density between adjacent radargrams, solid 3D vector volumes can easily be generated and interpolated onto from the vector radargrams using the XYZA Vector compilation in the Slice/Resample menu. An example

of a column radial surveys and the 3D interpolated vector volume is shown in Figure 6. Prior to this new vector volume option, the ability to create this volume required specialized rectangular volume warping. This new feature of generating the vector volume from 3D interpolation is the far superior and complete method for these simple vector spaces.

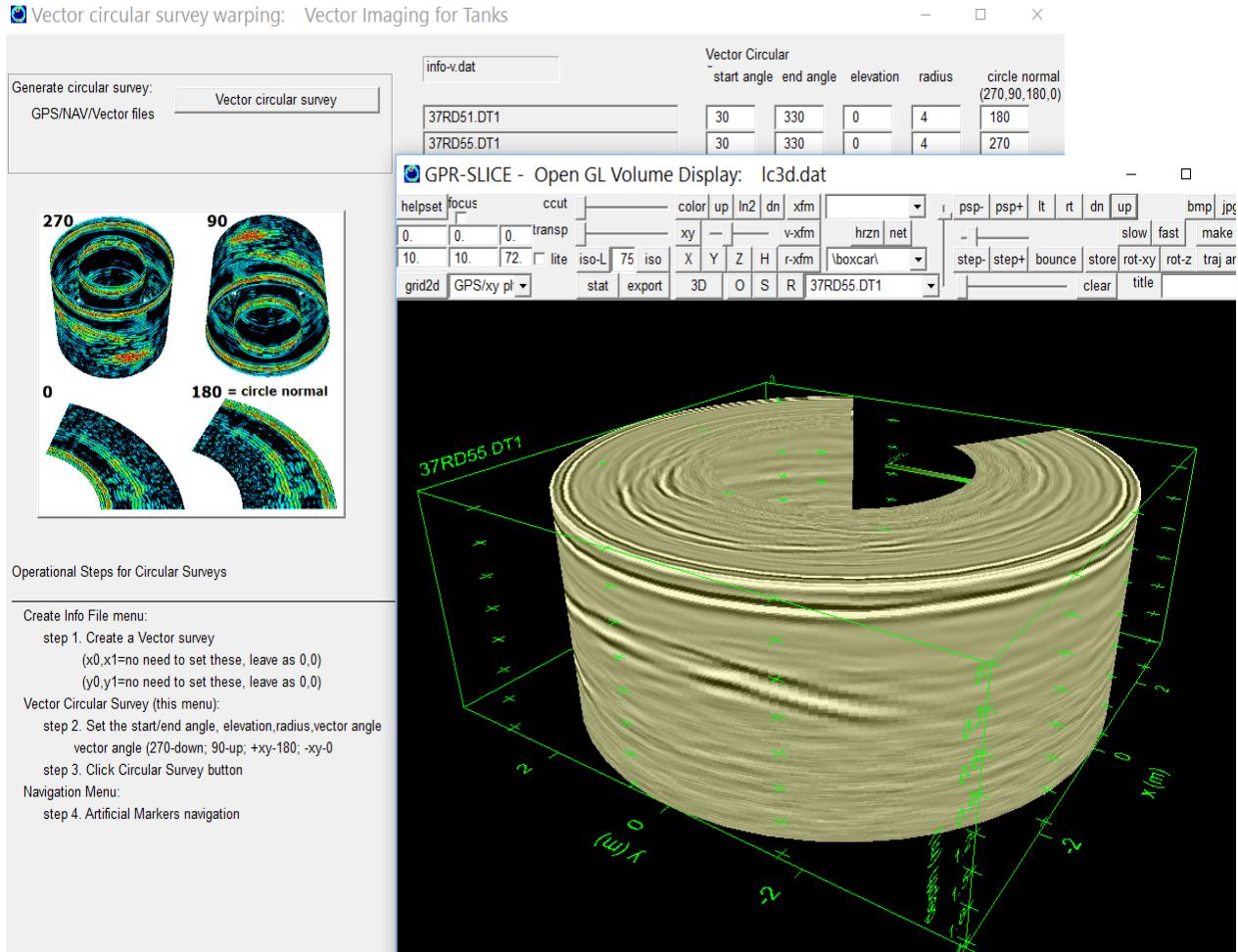


Figure 5. Vector imaging on circular features such as tanks or columns is made easier with a new menu to set vector normals, radii and start/end angles.

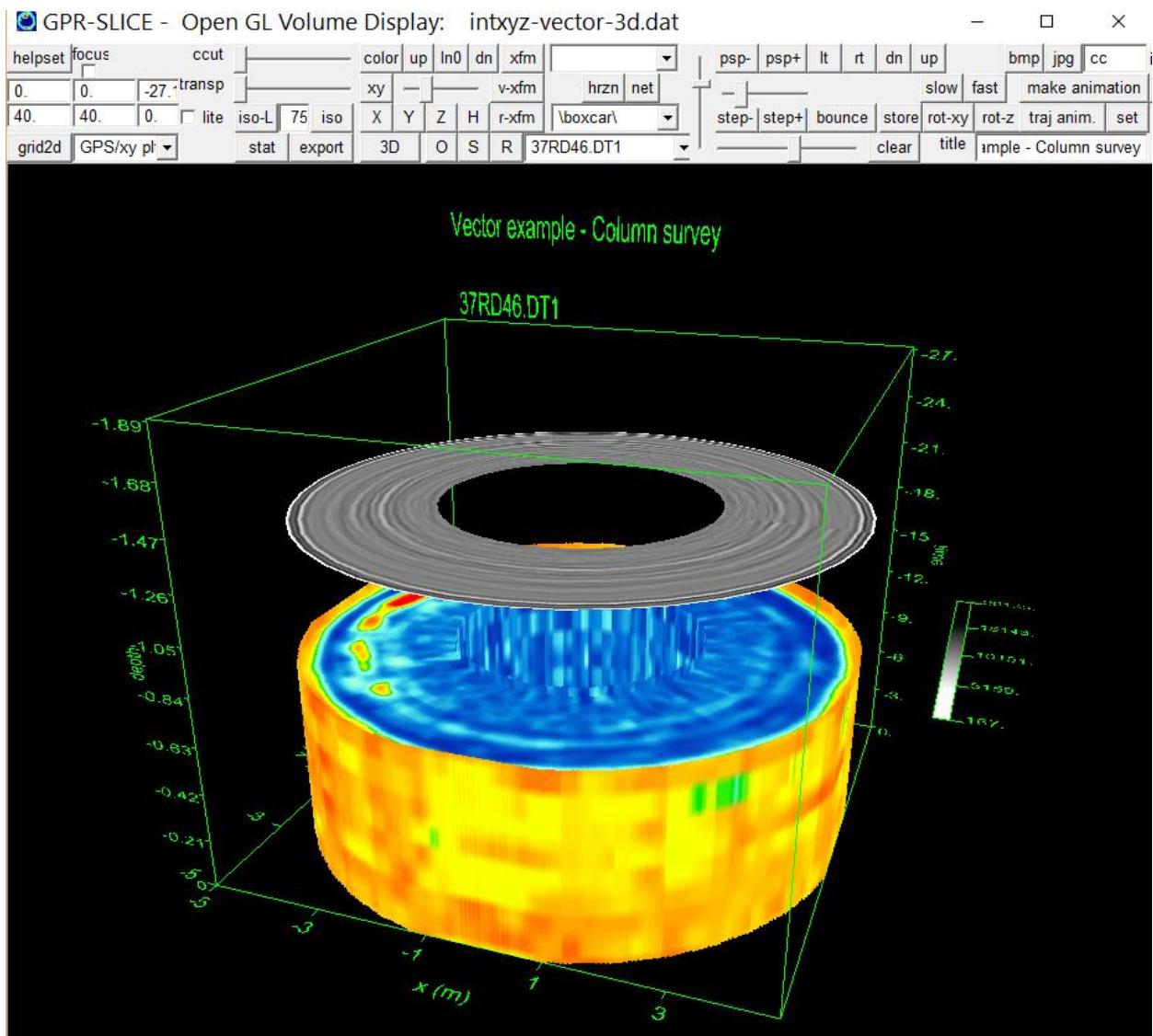


Figure 6. Example of a radial column survey with a vector radargrams and a 3D interpolated vector volume.

## **Auto Storage of Google Maps in OpenGL Volume**

GPR-SLICE can now automatically retrieve a Google map for GPS datasets. A new executable which is shelled out to call googmap.exe, will read the 3D volume and center a Google map on the grid. The zoom level of can be set before storing the map (Figure 7). A value of 18 for instance will give a typical distance of around 450 meters over the image which defaults to 1000x700 pixels. The pixel size can be increased to values just slightly less than the full native screen resolution of the display. If higher resolution is needed choose a zoom level of 19 or use a denser display monitor. A zoom level of 17 can be used to make a bitmap overlay that shows more of the surrounding area at the site. To generate the sitemap.bmp, simply close the Google Map dialog to store the bitmap to the main project folder. Animations on top of the image or various other displays are all possible. An example from the Saitobaru National Burial Mound in Miyazaki, Japan are shown overlaid on the Google map retrieved from the new menu option (Figure 8). A GPS radargram from the Strawtown Archaeological Site in Indiana is shown in Figure 9 overlaid on top of the sitemap.bmp imported from Google Maps. An example of an isosurface on a sitemap.bmp is shown in Figure 10.

In the BMP Overlay menu, the depth of the sitemap.bmp can also be adjusted on import. The depth is currently set as a graphical input from -0.5 to +0.5 where 0 is half way between the 3D volume depth. Time slices below the image depth will be masked as will displayed radargrams. The transparency slider bar can be used to look through the sitemap.bmp. If one is doing 2D flat displays you will need to place a little bit of transparency to see the time slices on top of the sitemap.bmp

Note: This new option does require an internet connection, so it is best to download your desired images before going to a remote field site. The Google map dialog should not be maximized and the default dialog size should be left stationary. Zoom levels should be set before launching Google maps.

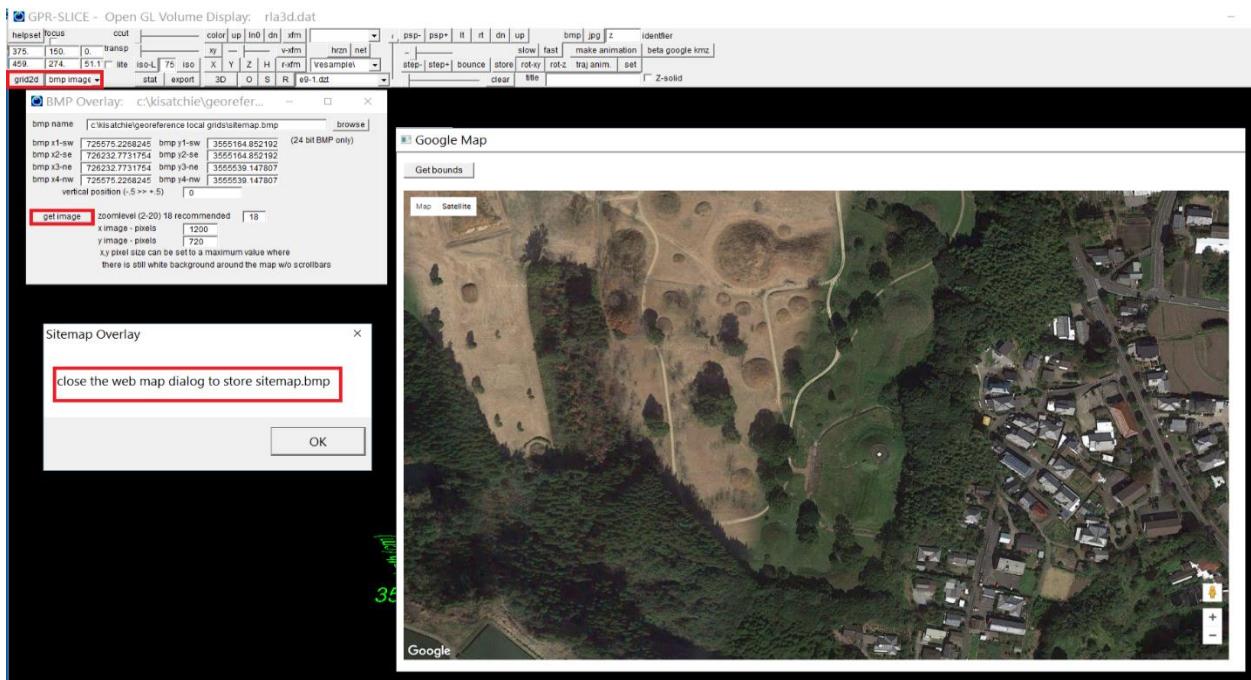


Figure 7. Option showing import of a Google Map in OpenGL Volume.

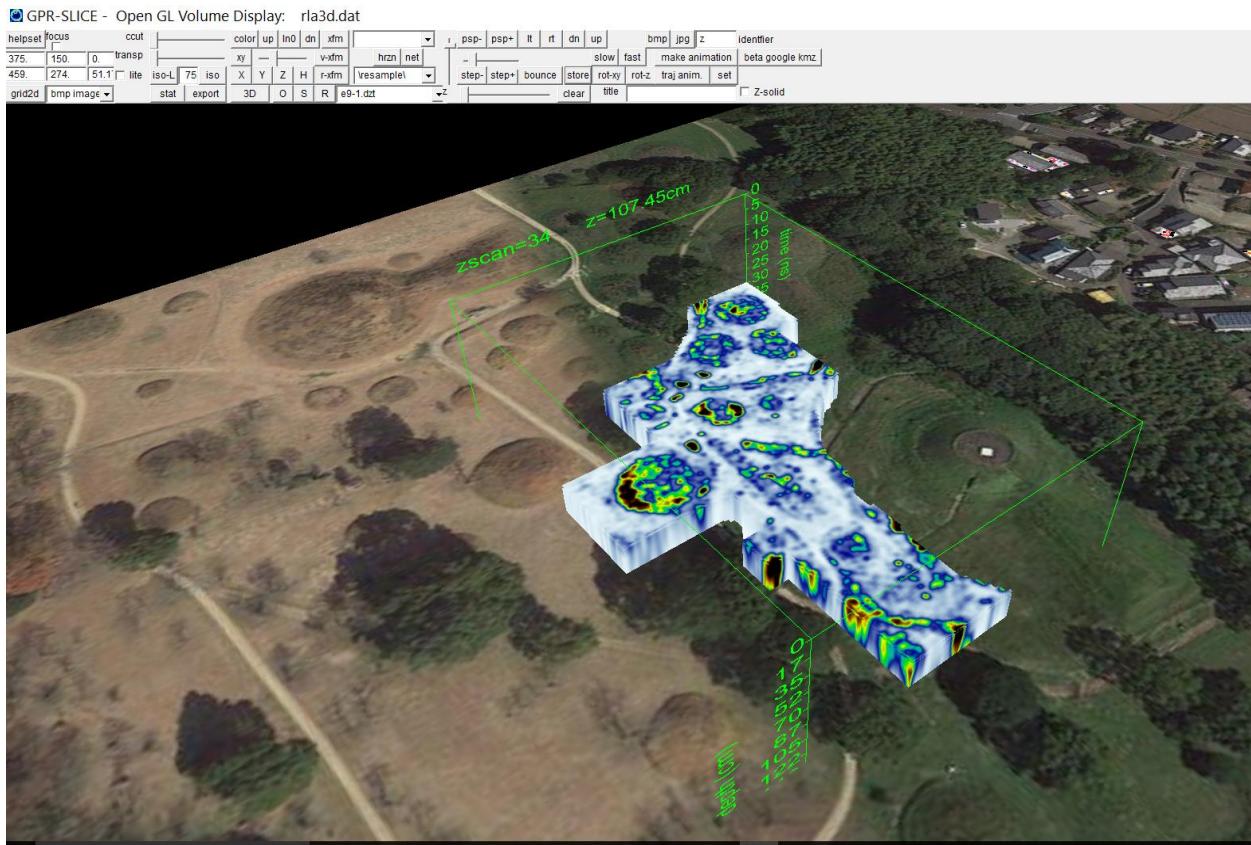


Figure 8. Solid 3D volume time slice shows on top of a Google Map at the Saitobaru National Burial Mounds in Miyazaki Prefecture, Japan.

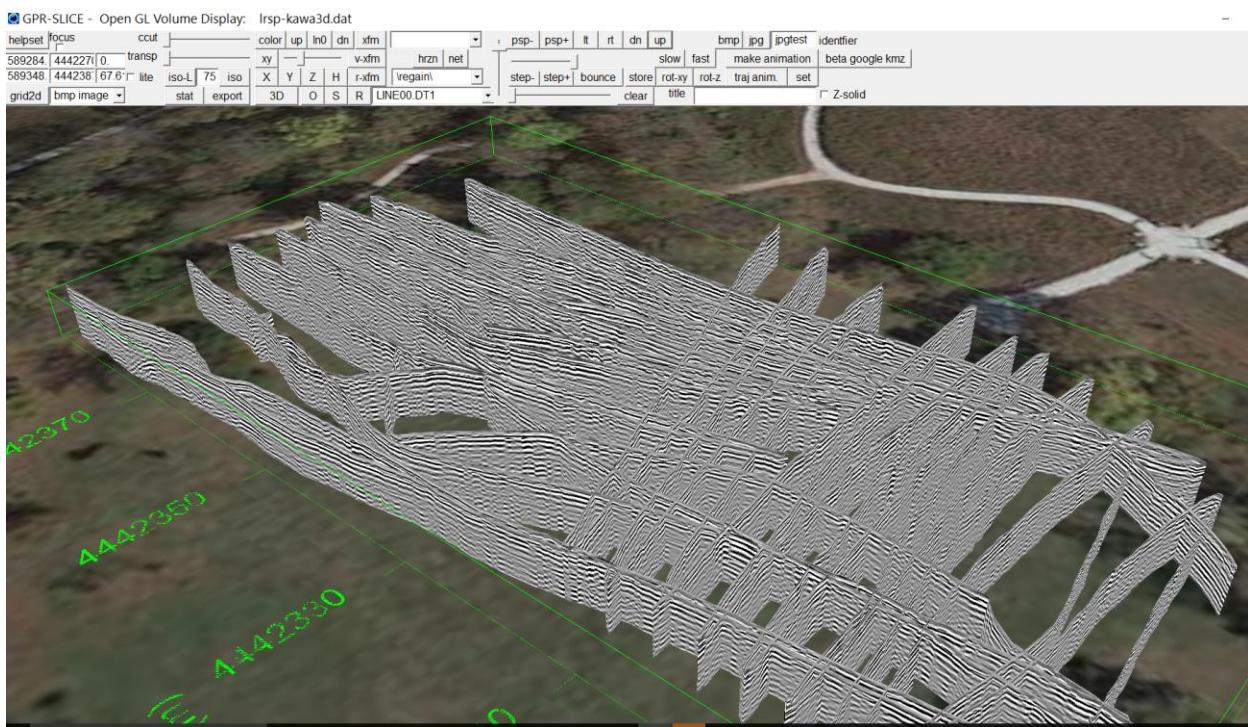


Figure 9. A 3D GPS radargram from the Strawtown Archaeological Site in Indiana.

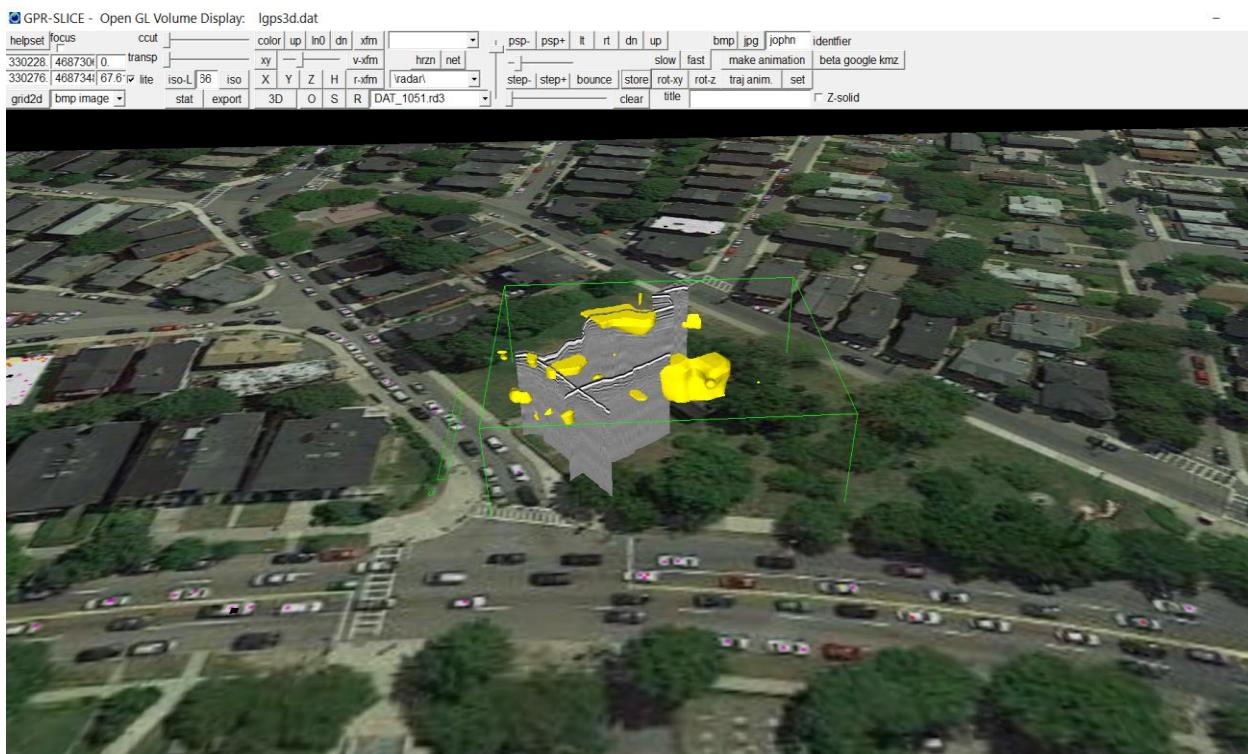


Figure 10. Example of GPS radargram and an isosurface on top of a Google sitemap.bmp from a survey taken in an open field in an urban area.

## **Combining multi-frequency antennas**

A new option is available in the Analytics pulldown menu to combine low frequency and high frequency antenna (Figure 11). The operation will combine either dual frequency or triple frequency radargrams. For some manufacturers the time windows are different between the low and high frequency channels. For dual frequency operations the high frequency and low frequency information files must be named infoa.dat and infob.dat with infob.dat being the low frequency channel (the channel with the longest time window). For triple frequency blending (such as for data from US Radar's Quantum Imager system or from UTSI Electronics), the software looks for infoa.dat, infob.dat and infoc.dat with infoc.dat being the low frequency channel having the deepest time window.

To accommodate for the variability in time window and pulse digitization between the different antennas, the software operation will automatically scan resample the high frequency channels and make separate channels with equal time windows. The bottom of the resampled channels will have null – 0 data. The filename for these generated channels is appended with the name "comp-" to signify compression – which is essentially the mathematics that is applied to match the digitization of the time windows for each channel. These scan resampled radargrams with the "comp-" identifier are written to the exact same processing folder highlighted.

After the operation is run 2 separate information files are written. For combining just 2 frequencies the software will generate the infoant3.dat and the infoant123.dat files. Infoant3.dat has just the name of the combined radargram which is appended with the name "ba" on the blended radargrams. The information file "infoant123.dat" will contain the names of the low frequency resampled channel, the high frequency channel and the combined radargram name. Similarly, for combining 3 antenna frequencies, the info file names generated are infoant4.dat and infoant1234.dat which will have the combined radargrams and the separate 3 frequencies and the resultant radargram. The infoant123.dat and infoant1234.dat files will make it easy to examine all the separate frequencies and the combined radargram for viewing in the Radar 2D menu.

Note: Currently the operation assumes that time 0ns is the same between the different antenna. If time 0ns is significantly different, then radargram editing operations should be run prior to combining the different antenna frequencies. Each antenna can also be blended with their own multiplier constant. If the constants are set to 1 for each channel, there is a potential for the combined radargram to have clipped pulses that go beyond the binary resolution of the data recording. In this case, one might opt to set each antenna multiplier to 0.333 for the combining operation.

GPR-SLICE Ground Penetrating Radar Imaging Software: Murphy help

File Reverse Navigation Slice Grid Pixel Radar 3d volume Filter Static Animation Help

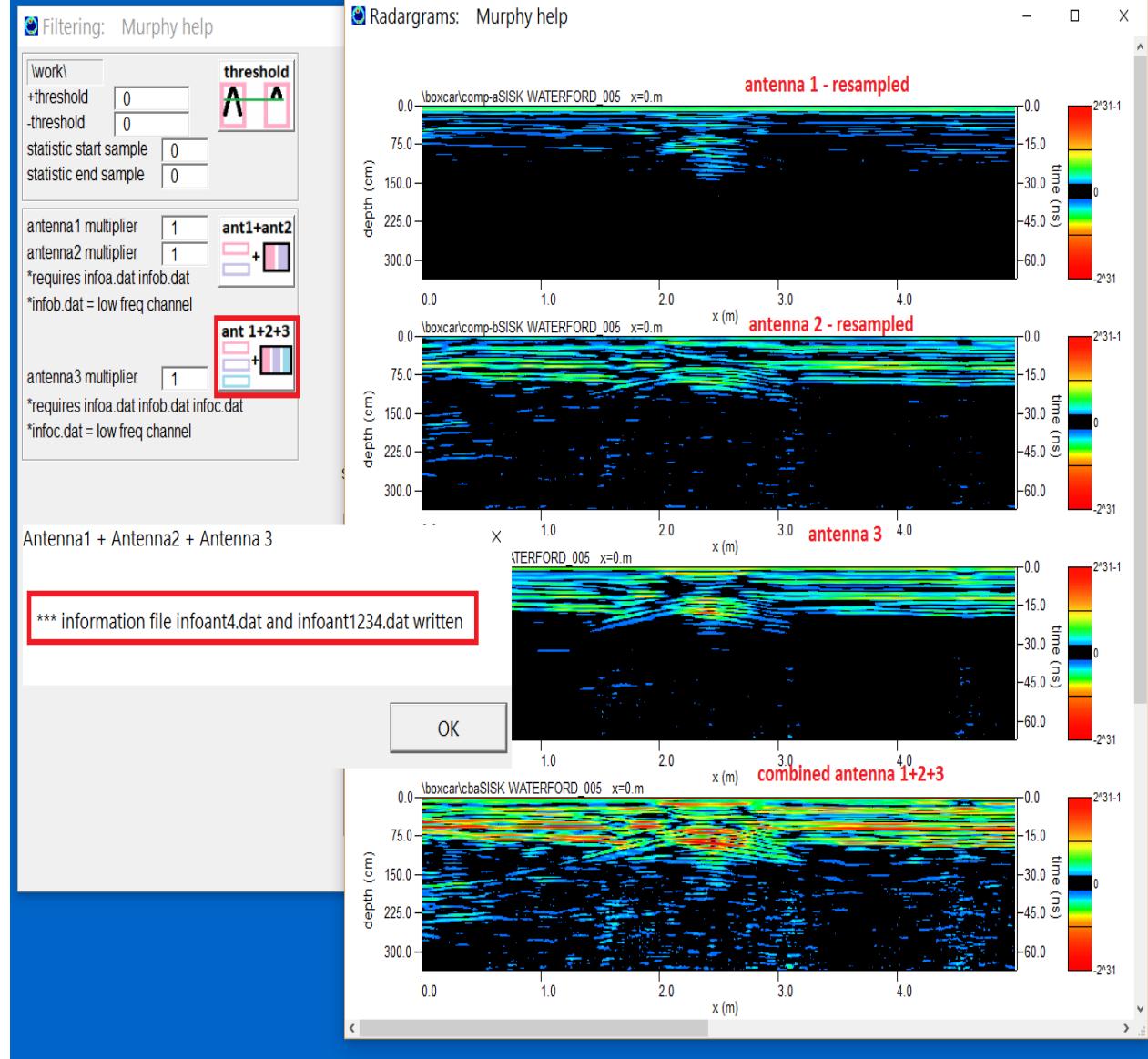


Figure 11. Example of the new option in the Analytics menu for combining either dual frequency radargrams, or triple frequency radargrams.

## GPS post processing from a Master.gps file

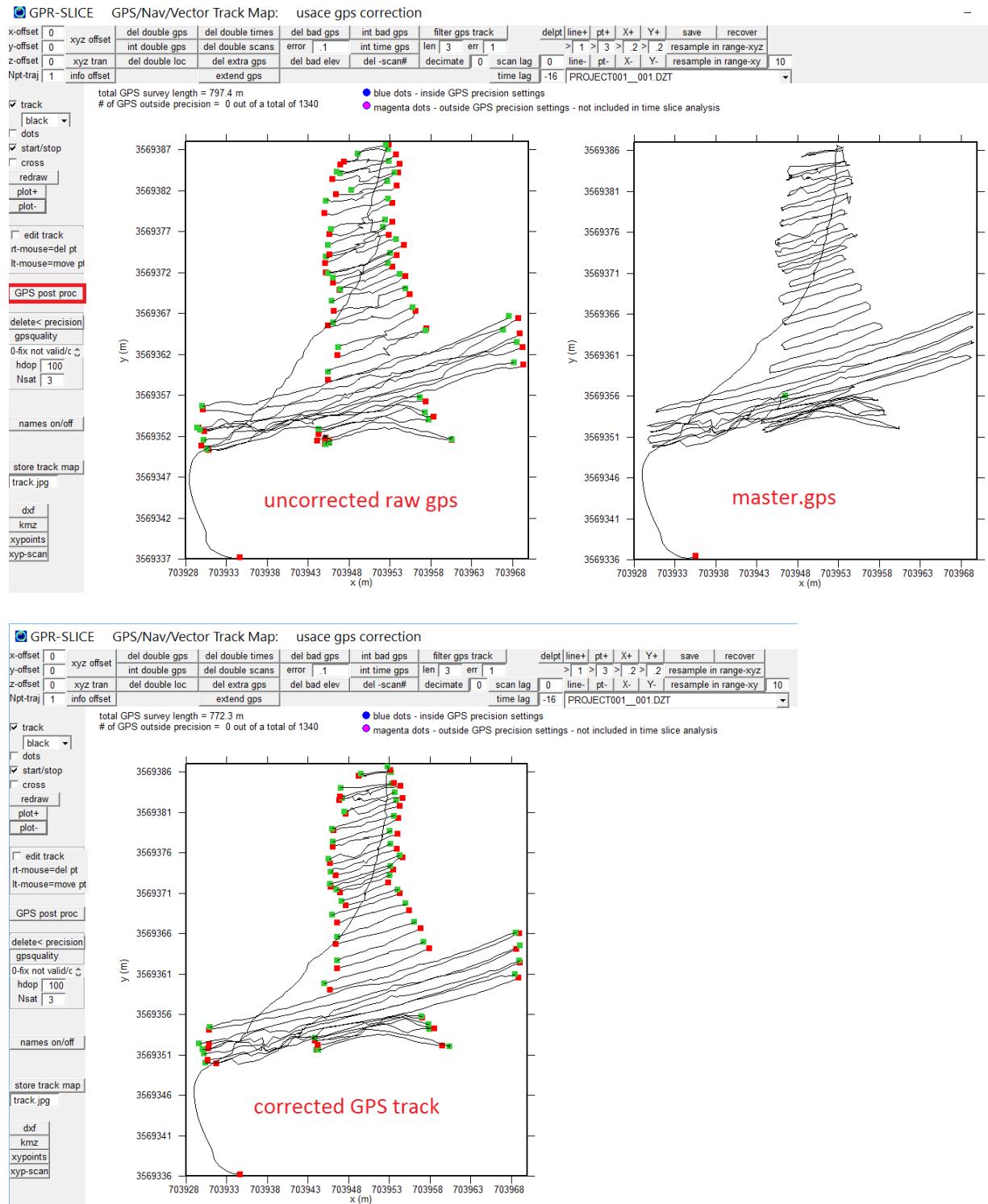


Figure 12. GPR Post Processing master.gps track is used to correct individual GPS raw navigation using the new GPS Post Proc button operation in the GPS Track menu.

The GPS Track menu can now be used to post process raw uncorrected GPS tracks. Typically, a GPS survey will be made where a single GPS track from a secondary – master GPS log file that is recorded simultaneously and which is later post processed to yield a corrected GPS track. GPR-SLICE will now merge a corrected master.gps track with the raw uncorrected GPS tracks for each of the files in the project. The master.gps file should encompass the entire time that comprises the individual GPS files. A new button called GPS Post Proc in the menu will read the uncorrected GPS track for each radargram and will extract the time (Figure 12). This time is then used to go into the master.gps processed track to extract the exact location. Linear interpolation is made between the 2 bordering times in the master.gps to yield the best possible corrected track.

Note: the master.gps is a single recorded GPS over the entire survey time. The file is 4 columns with time, eastings, northings and elevation – comma delimited, and should reside in the \raw\ folder of the project.

## GPS Full Scale, Equidistant Scale, and 1scan-1pixel Scale

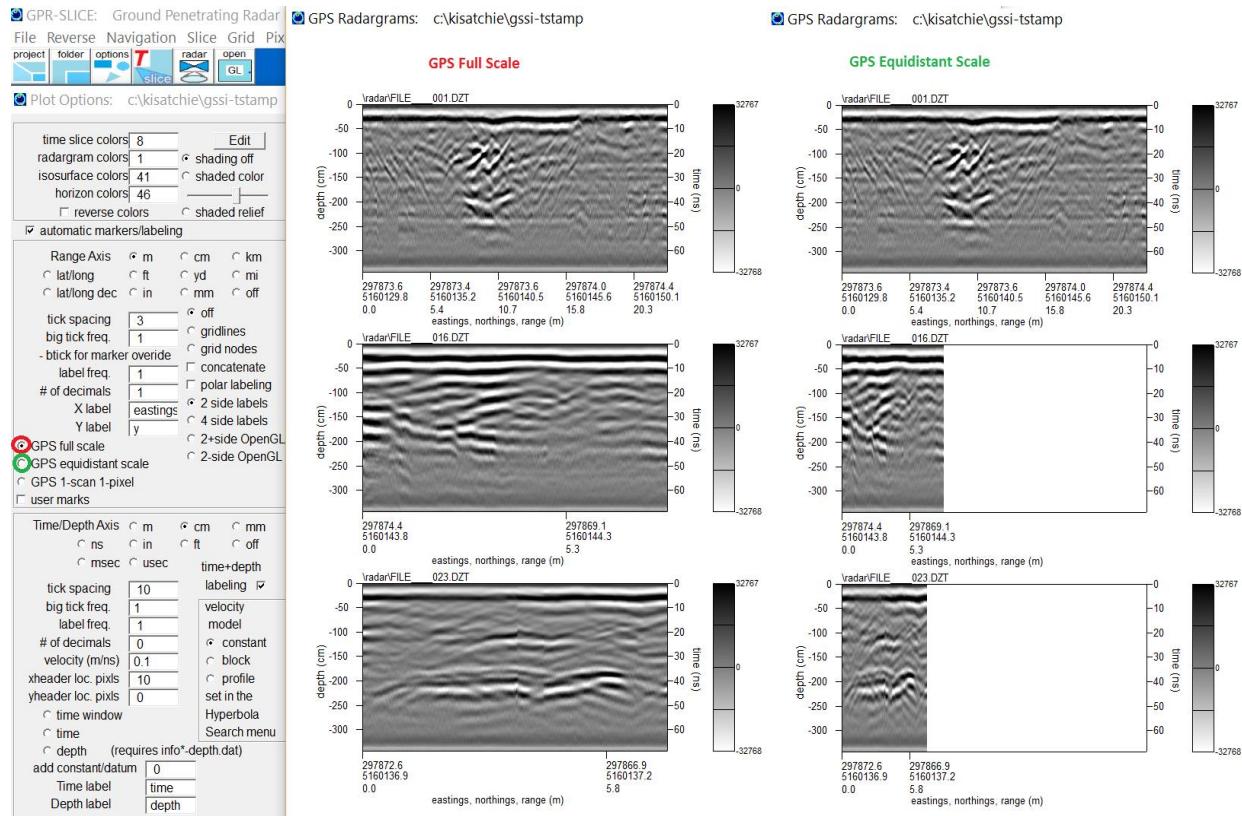


Figure 13. Location of GPS radargrams display options for GPS Full Scale, GPS Equidistant Scale and GPS 1-scan 1-pixel in the Options menu.

GPR-SLICE now has new options for multi- GPS radargram displays. There are 3 choices called GPS full scale, GPS equidistant scale, and GPS 1-scan 1-pixel scale. GPR full scale will show GPS radargams completely across the desired width of the graphic pixel length chosen (Figure 13). If some radargrams have very few GPS readings or more scans, regardless of the differences, each radargram plot will be shown with the same horizontal graphic scale. If GPS equidistant scale is chosen, the radargram will be scaled by how many GPS readings there are for each radargram and the GPS start and GPS end settings on the Radar 2D menu. This display will help to better show the relative sizes of features with the same number of GPS points per horizontal length. The option GPS 1-scan 1-pixel scale will show one scan per pixel. This display will be similar to the GPS equidistant scale option but will display whatever number of scans there on each radargram horizontally. For some graphic cards there could be a limit and probably radargrams with more than 50k scans should not be used. If radargram with more than this, the GPS 1-scan 1-pixel option can be used alternatively with the Segment option to show vertical columns of the same radargrams made in segments.

### **Other features and options added to GPR-SLICE include:**

- Detected horizons shown in the multi-display Radar 2D menu with a new flag checkbox in the Options menu (Figure 14)
- \$GNGGA NMEA string import option in the Create New Info menu
- Additional DXF file with absolute elevations written but with active labeling showing relative depth from the ground surface
- Export of complex power spectra written to ASCII file, Bandpass menu
- Standard Stereo Lithography CAD software export \*.STL extension of isosurfaces added to OpenGL Volume menu (Figure 15)
- Auto hyperbola search menu updated with amplitude reduction slider bar (available for licenses with the Bridgdeck module)
- Extend GPS button added to GPS track menu to predict the UTM on each side of the first and last tagged GPS marker that is not at the beginning or end of the scan data
- Constant gain button added to all convert and regain menus.
- Unit per Marker has been converted to floating point precision and now supports decimal description and is not limited to integral definitions
- Ricker wavelet added to Impulse Response menu for spectral deconvolution option
- Multichannel info file creation enhanced with help set button for quick setting of constant channel separation and naming convention
- Number of junctures for adjusting bandpass setting doubled for making sharper frequency cutoffs

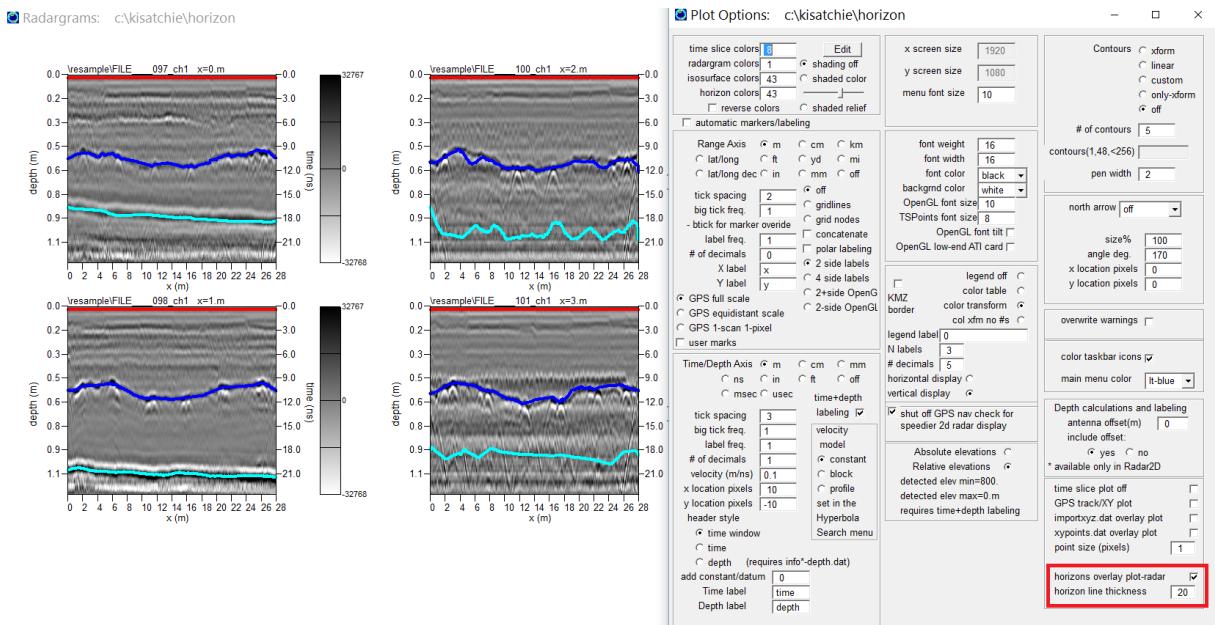


Figure 14. Example of the new display capability to overlap all the detected horizons in the Radar 2D menu using the Options menu checkbox.

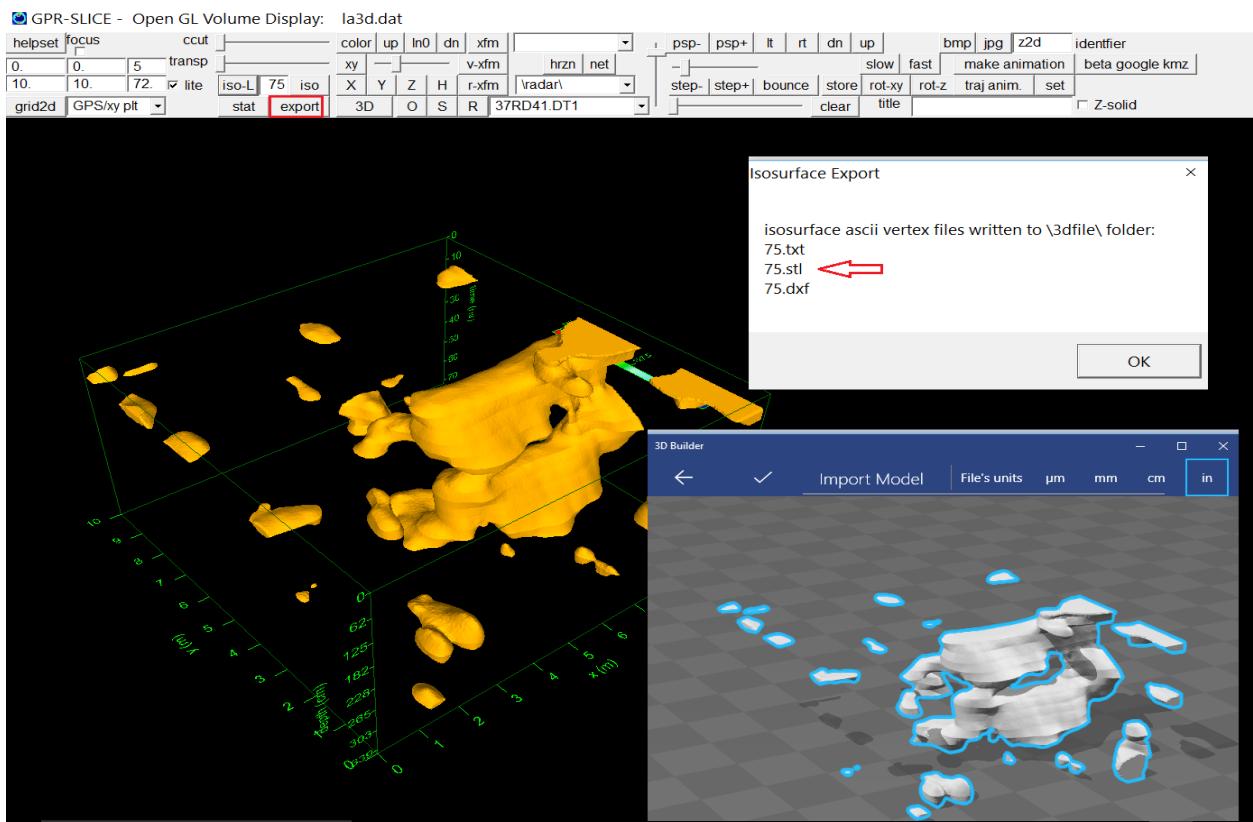


Figure 15. Example showing the export of OpenGL Volume isosurfaces to \*.stl file format for input to other display software.

- Help Slices and Help Thickness buttons added to Slice/Resample menu (Figure 16)
- Zero crossing + thresholding method for time 0 detection added to Radar Edit menu.
- Import new data files with an append identifier in the Transfer Data menu (useful for multiple side-by-side grids with the same radargram filenames to process all together)
- Statistic pixel count file written after running the Thresholding filter under the Analytics menu along with options to set start and end samples for statistic evaluation. (Figure 17. Accessed through the Filter pulldown Analytics menu)
- 3D Hilbert transform direct volume filtering available in the Filter3D menu (Figure 18).
- Adjust navigation to single marker control line navigation – is a new option to fix survey wheel lengths in the information file to a common control line across a site reading a single fiducial marker on a radargram – available in the Edit info File menu

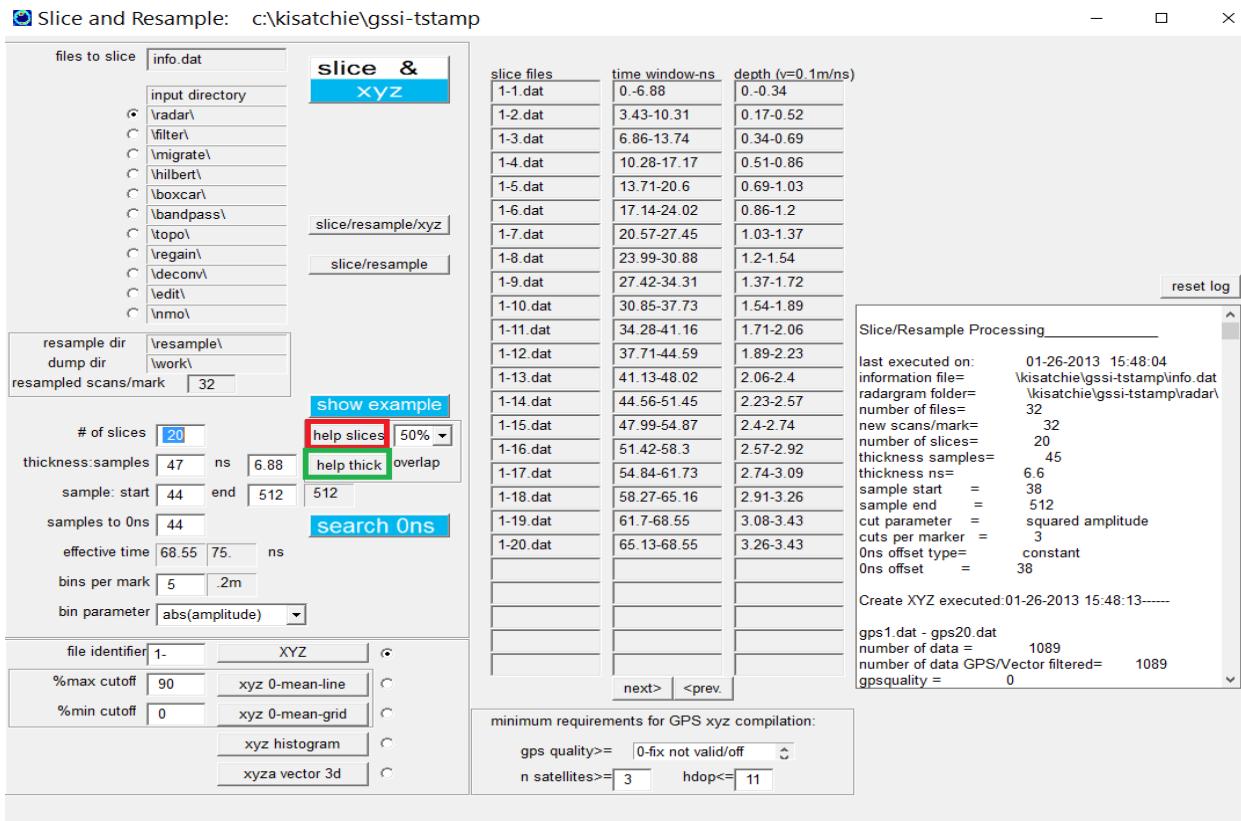


Figure 16. Location of the new Help Slices button to assist in calculating the number of slices given a set thickness. The traditional button - now named Help Thick - will calculate the corresponding time slice thickness in samples given a set number of slices.

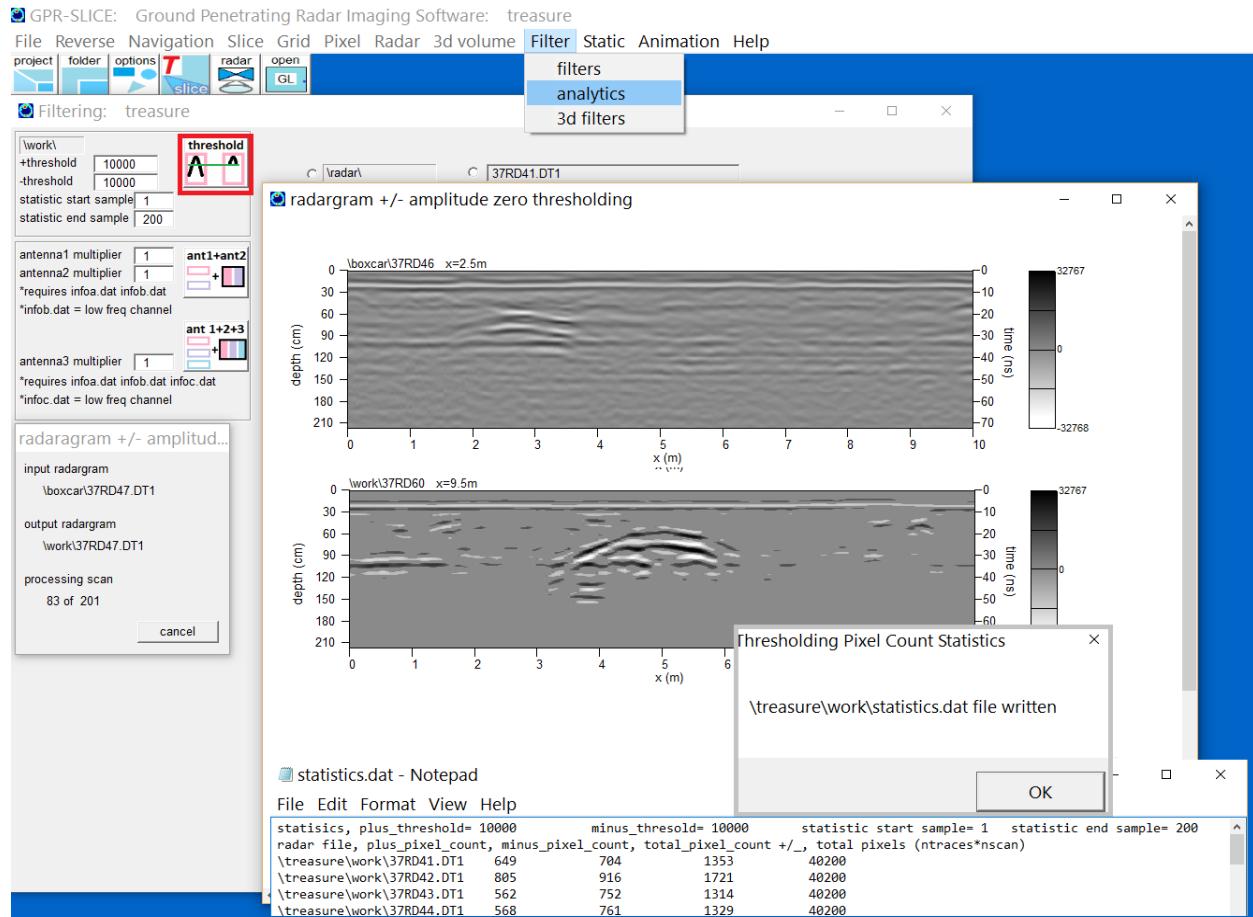


Figure 17. Location of the radargram thresholding option and statistics file writing in the Analytics menu.

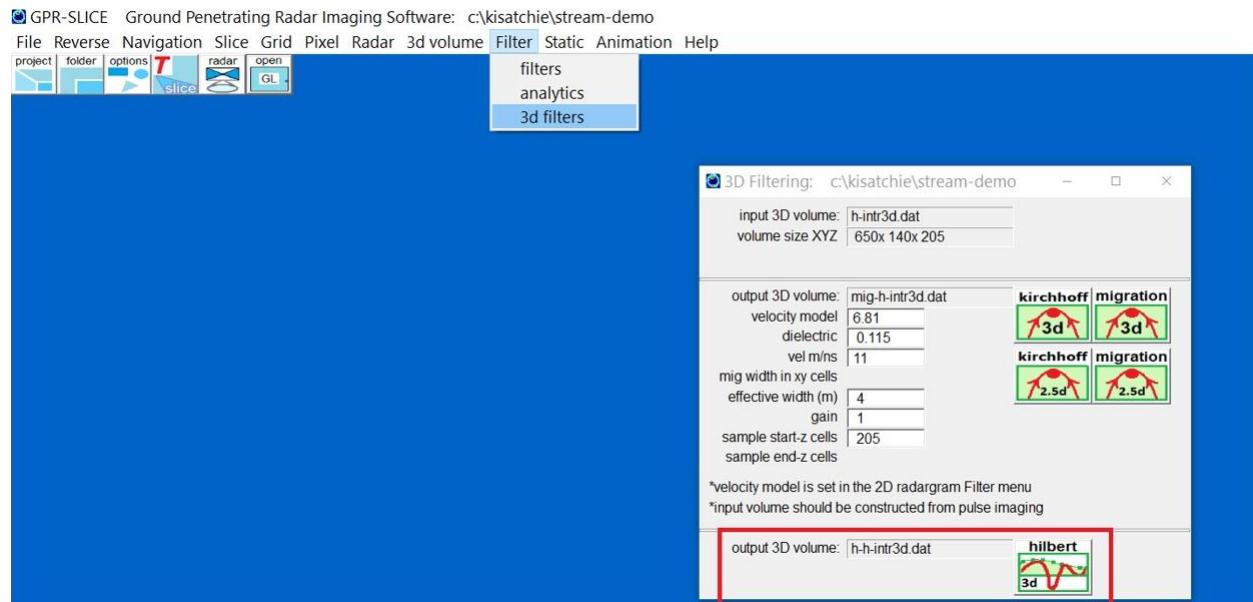


Figure 18. Location of the new 3D Hilbert Transform filter.

## Upcoming and Previous Events

GPR-SLICE was exhibited at GPR 2016 at the Hong Kong Polytechnic University in June. Since GPR 2016 11 new organizations directly related to the conference have signed on to the software. We are very grateful to Dr. Lai Wallace for hosting a great conference.



The GPR-SLICE 2-day Advanced Workshop was hosted at Texas A&M University by Dr. Dirk Hays of the Agrilife Research Department on March 27-28 this year. There were 25 attendees that came to the workshop. Dr. Alex Novo and myself were the trainers for the event. There was also an IDS Stream multichannel demonstration made by Alex during the workshop.

We are now accepting sponsorship for the next GPR-SLICE 2-day workshop. If there are any universities or organizations that are interested in hosting the next GPR-SLICE workshop that can handle up to 30 attendees, please let us know. The dates for the workshop are flexible in either late fall or in the winter and would be based on the level of interest.

## **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 GPR-SLICE software topics. All the new options have been first introduced in the Facebook forum for GPR-SLICE right at the time they were developed and released. If you have not yet joined the GPR-SLICE Facebook page, I would encourage you to do so at:

<https://www.facebook.com/groups/qpr.slice/>

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Dean Goodman  
GPR-SLICE Software

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