Release notes Rayfract® versions 2.61 to 4.03 :

Version 4.03 released in Oct 2022 :

- Oct 14, 2022 : Bernal et al. describe Geophysical Analysis of Soils and its Contribution to Disaster Risk Reduction for Millhuish area and for Challhuayaco area, San Marcos District, Huari Province in Peru (Instituto Geofisico del Peru 2022, in Spanish).
- Oct 12, 2022 : added more figures and updated figure captions in new checkerboard test tutorial .
- Oct 9, 2022 : updated Surfer plot titles and figure captions in our new checkerboard test tutorial. Added more figures showing DeltatV, XTV and WET dialogs and settings menus.
- Oct 9, 2022 : added links to DropBox .RAR archives in our new checkerboard test tutorial.
- Oct 5, 2022 : review our new tutorial showing ***checkerboard resolution test*** for our sample profile TRA9002 using multiscale Conjugate-Gradient WET inversion with WDVS@250Hz (Wavelength-Dependent Velocity Smoothing, Zelt and Chen 2016).
- Sep 30, 2022 : renamed parameter ***Weathering crossover*** in *DeltatV|Interactive DeltatV|Static Corrections* dialog to ***Basement crossover*** to discourage user from decreasing this parameter too much below default value of 10 stations. Updated status bar prompts and error messages.
- Sep 29, 2022 : Handoyo et al. show Characterization of the shallow subsurface structure across the Carrascoy Fault System (SE Iberian Peninsula) using P-wave tomography and Multichannel Analysis of Surface Waves (Geologica Acta, Sep 2022). See also Handoyo et al. Geophysical Imaging of the Critical Zone along the Eastern Betic Shear Zone (EBSZ), SE Iberian Peninsula (Applied Sciences, March 2022).
- Sep 28, 2022 : improved error prompt “Degenerated starting model grid !” when long refraction line starting model grid has too few rows. Show column and row counts in prompt.
- Sep 26, 2022 : regard Golden Software Surfer limit of max. 32,767 grid columns and max. 32,767 grid rows when generating **`.GRD`** grid file for initial/starting model for Pro license and with long lines e.g. with marine refraction lines.
- Sep 26, 2022 : improved prompt “Needed to increase forced grid cell size” now showing adjusted grid column and row counts. Force the grid cell size in *Header|Profile*. See 3016 tutorial Fig. 2.
- Sep 26, 2022 : Hogan and Margrave describe frequency-dependent Gaussian velocity smoothing (Crewes Research Report, Vol. 19/2007). This relates to our *WDVS smoothing* (Wavelength-Dependent Velocity Smoothing, Zelt and Chen 2016) using a Cosine-Squared smoothing function.
- Sep 17, 2022 : we added a slide to our 2018 Sinalunga work shop PowerPoint file showing Multiscale Conjugate-Gradient WET inversion of TRA9002 profile using DeltatV starting model & WDVS@250Hz. Here is the .pdf version.
- Sep 17, 20022 : added more figures to NGU_G1 tutorial. In Fig. 36 we show multiscale WET inversion using our earlier optimized DeltaV+layered XTV starting model (Fig. 25). We enable WDVS (Wavelength-Dependent Velocity Smoothing; Zelt and Chen 2016) for sharper imaging of known fault zones in the basement.
- Sep 16, 2022 : select new option ***File|Update data Settings|Don't apply shot delay and trigger delay to imported traces with 'Update Shotpoint coordinates' command*** when updating traces imported from ASCII.ASC with .SHO file listing shot delay and trigger delay for SEG-2 or SEGY traces for same profile. When exporting to ASCII.ASC the shot delay and trigger delay is already included in the exported first break traveltimes.
- Sep 12, 2022 : always regard *Min. elevation* specified in *Grid|Surfer plot Limits* during multirun WET inversion.
- Sep 9, 2022 : our SEG-2 import now supports 64-bit floating point sample format. Tested with ABEM Terraloc Pro 2 .SG2 files. All sample formats are converted to 32-bit floating point format when storing imported traces in the profile database.
- Sep 9, 2022 : improved display of wait cursor with new *WET progress dialog*.
- Sep 9, 2022 : show cancelled WET inversion during *WDVS smoothing* in status bar.
- Sep 7, 2022 : keep *WET progress dialog* with *Cancel* button alive during *WDVS smoothing*.
- Sep 7, 2022 : tested latest 4.03 and 4.03 Pro in Windows 10 Pro 32-bit 21H2 under Parallels with Surfer 11 free demo.
- Sep 4, 2022 : tested latest Golden Software Surfer Beta version 24 in Windows 7 64-bit & Windows 10 64-bit Pro with our latest version 4.03.
- Sep 4, 2022 : Trebsche et al. describe Combining geophysical prospection and core drilling: Reconstruction of a Late Bronze Age copper mine at Prigglitz-Gasteil in the Eastern Alps (Austria) (Archeological Prospection, Aug 2022).

- Sep 4, 2022 : Censini et al. describe Seismic tomography: A Vital Tool in the Preliminary Investigation Stage of any Hydropower Plant. Examples of Two Large Projects in Ethiopia: the Gibe III and the Grand Ethiopian Renaissance Dam Projects (Georisorse Italia Sas, 2013).
- Aug 27, 2022 : Justin Anning describes Comparing Sub Bottom Profiling and Seismic Refraction Tomography Results and Interpretations for Coastal Marine Geotechnical Projects (EEGS FastTIMES, Aug 2022).
- Aug 19, 2022 : recheck for heap leaks in Compuware HeapAgent for Win32 version 10.01 in Microsoft Visual Studio 2005 debug build. No new leaks or memory array boundary overwrites found.
- Aug 18, 2022 : terminate multirun WET inversion early if user clicks *Cancel* button in new *WET progress dialog*.
- Aug 13, 2022 : tested our latest Pro version 4.03 in Windows 10 21H2 running under VMWare Fusion 12.1.0 on Apple Intel 2018 macMini with WET option ***Enable AWE physical memory page caching*** checked. Run as Admin as shown in our AWE configuration .pdf.
- Aug 12, 2022 : show progress of WET inversion in ***new WET dialog with progress bar***. Allow early termination of WET with *Cancel* button. The last WET iteration completed is plotted in Surfer.
- Aug 12, 2022 : we now refresh *Refractor|Shot breaks display* when semi-automatic/polyline picking shot gather trace segments with option ***Processing|Refresh shot breaks when picking traces*** checked.
- Aug 11, 2022 : tested our latest version 4.03 in Windows 10 21H2 running under VMWare Fusion 12.1.0 on Apple Intel 2018 macMini.
- Aug 9, 2022 : faster invocation of Golden Software Scripter for plotting of tomograms and wavepath coverage plots. Helps with multirun WET inversion under Windows 10/11 64-bit.
- Aug 9, 2022 : we now refresh the opened *Refractor|Shot breaks display* after automatic picking with **ALT+B** in *Trace|Shot gather* with option ***Processing|Refresh shot breaks when picking traces*** checked.
- Aug 9, 2022 : our new dialog ***Grid|Edit shot labeling parameters*** allows forcing of the vertical offset between shot labels for shots positioned at same offset.
- Aug 6, 2022 : review an updated description of Microsoft Address Windowing Extensions supported with our Pro version. This allows accessing all installed RAM memory on your PC above 4GB limit. See our instructions on how to enable AWE for our Pro version software.
- July 31, 2022 : updated paragraph *Conclusions* in Aaknes-1 tutorial on last page.
- July 30, 2022 : view our updated help chapter on DeltatV inversion describing renamed control *Basement crossover* in *DeltatV|Interactive DeltatV|Static Corrections* dialog.
- July 29, 2022 : further updated help chapter on *Pseudo-2D DeltatV / Static corrections* dialog.
- July 29, 2022 : review Flinchum on What Do P-Wave Velocities Tell Us About the Critical Zone ? (Frontiers in Water, Jan 2022).
- July 28, 2022 : Shams describes The use of Surface Wave methods in terrain susceptible to shallow land slides in the city of Campos do Jordao, Brazil (thesis Univ. Sao Paulo, 2016).
- July 28, 2022 : Camacho describes Caracterización geofísica del sistema de fallas Alhama Murcia (FAM). Transepto la Torrecilla. Lorca, España (thesis Univ. de Granada, 2016).
- July 28, 2022 : improved WET error handling in connection with new WET progress dialog.
- July 23, 2022 : renamed DeltatV parameter *DeltatV|Interactive DeltatV|Static Corrections|Weathering crossover* to ***Basement crossover***. This emphasizes that this parameter must not be decreased (from default 10 stations) to avoid over-correction of basement-refracted arrivals to floating datum using too low *overburden velocity* obtained from this crossover value especially with strongly undulating topography and with too wide *Topography filter* parameter. See our NGU_G1 tutorial Fig. 30.
- July 23, 2022 : retest 4.03 in updated Windows 11 21H2. As fast as in Windows 7 64-bit Pro now.
- July 23, 2022 : redo profile-guided optimization for latest version 4.03 builds in Visual Studio 2022 Pro. Make sure new progress dialog display does not slow down WET inversion.
- July 22, 2022 : rebuilt our latest version 4.03 in Microsoft Visual Studio 2022 Pro version 17.2.6. Tested in Windows 10 21H1 and Windows 7 64-bit Pro.
- July 21, 2022 : review our updated .pdf help chapter *Picking first breaks*. We describe how to pick shear-waves on the last two pages, using our *Trace|Shotpoint gather* display.
- July 20, 2022 : write new *DeltatV settings* to **.PAR** file and restore from **.PAR** file.
- July 19, 2022 : added step-by-step instructions to NGU_G1 and Aaknes-1 tutorials on how to obtain NGU pessimized DeltatV interpretations using bad **DELTATV.PAR** files made available by NGU on July 4th, 2022. Compare against NGU_G1 DeltatV with default static corrections & layered XTV inversion and compare with default Aaknes-1 DeltatV.
- July 16, 2022 : updated figure captions and text on last page in Aaknes-1 tutorial.
- July 15, 2022 : view our latest help chapter on XTV inversion and parameters. We used the free CutePDF writer driver in Windows help viewer with *File|Print Topic* command to generate the .pdf .

- July 14, 2022 : view our latest help chapter on DeltatV inversion.
- July 14, 2022 : our updated free trial allows using *DeltatV|XTV parameters* dialog settings with *DeltatV|Automatic DeltatV* and comes with latest help file.
- July 14, 2022 : added *DeltatV|DeltatV Export options* dialog to edit export options without having to go through *DeltatV|Interactive DeltatV* main dialog. Use with *DeltatV|Automatic DeltatV*.
- July 14, 2022 : review .png showing latest help on *DeltatV|DeltatV Settings* menu items
- July 13, 2022 : review .jpg showing latest help on *DeltatV|Interactive DeltatV* main dialog
- July 13, 2022 : review latest help on *DeltatV|Interactive DeltatV|Static corrections* dialog
- July 13, 2022 : review latest help on *DeltatV|Interactive DeltatV|Export options* dialog
- July 11, 2022 : further updated help chapter on *Pseudo-2D DeltatV / Static corrections* dialog.
- July 10, 2022 : show *DeltatV inversion* with pessimized NGU DeltatV settings & parameters (Fig. 28) vs. our *Automatic DeltatV* (Fig. 29) in Aaknes-1 tutorial. Compare DeltatV **.PAR** files in Fig. 31.
- July 7, 2022 : further updated help chapter on *Pseudo-2D DeltatV / Static corrections* dialog. The *DeltatV weathering velocity* needs to represent the whole weathered overburden and not just the topmost "weathering layer" used in layered refraction interpretation with *Plus-Minus* method. So the DeltatV weathering velocity typically needs to be much higher than the layered refraction "weathering velocity". Otherwise *DeltatV static correction* will over-correct first breaks to floating datum especially with strongly undulating topography and strong topography curvature and with too wide *Topography filter* used for *Surface consistent* static corrections. The weathering/overburden velocity is estimated based on parameter *Weathering crossover*.
- July 6, 2022 : regard new *DeltatV|XTV parameters|Use above XTV settings for Automatic DeltatV* with *DeltatV|DeltatV Settings|Limit DeltatV velocity exported to maximum 1D-gradient velocity* checked.
- July 5, 2022 : added more figures to our latest tutorial NGU_G1 showing interactive DeltatV with pessimized DeltatV settings used by NGU for their 2020_044 report. Compare DeltatV settings.
- July 3, 2022 : updated help chapters *XTV inversion*, *Mapping traces to refractors* and *Pseudo-2D DeltatV / Static corrections* dialog options. Download & run our updated winhelp.exe installer.
- July 1, 2022 : added checkbox ***Use above XTV settings for Automatic DeltatV*** in *DeltatV|XTV parameters* dialog. Leave unchecked to force *Gradient model* XTV settings for *Automatic DeltatV*. See Fig. 27 in updated tutorial NGU_G1 .
- June 30, 2022 : added more figures to our latest tutorial NGU_G1 showing interactive DeltatV with layered XTV settings. Describe step-by-step how to obtain these figures.
- June 29, 2022 : you may want to configure your Parallels VM with ***Optimization, Resource usage*** set to ***Low*** to prevent spurious/bogus error prompts "Refractor not defined forward 0" e.g. with SAGEEP11 profile when mapping traces to refractors with ALT+L in *Refractor|Shot breaks*. These prompts can occur when running on 2011 MacBook Air with RAM memory issues or SSD issues and dead battery.
- June 28, 2022 : Garcia-Ocampo shows Resolution study of tomographic P-wave velocity models and geological interpretation at the Empordà basin (Thesis Univ. Barcelona 2017).
- June 28, 2022 : Marie Tungka shows Determining subsurface geology with seismic refraction tomography survey (2022 IOP Conf. Ser.: Earth Environ. Sci. 1003 012037).
- June 28, 2022 : added more figures to our latest tutorial NGU_G1 showing multiscale WET settings.
- June 27, 2022 : improved *File|Update header data|Update refractor branches from .BRN*
- June 27, 2022 : faster *Mapping|Delete branch points for all shots* in *Refractor|Shot breaks* display
- June 27, 2022 : our updated free trial allows export to .BRN and update with .BRN branch point files.
- June 26, 2022 : added more figures to our latest tutorial NGU_G1 with *Smooth inversion* output shown in Fig. 16 with RMS error 0.9%/0.55ms.
- June 25, 2022 : optimize DeltatV inversion in Fig. 4 in our short tutorial.
- June 23, 2022 : don't reset *DeltatV|Interactive DeltatV|Export Options|Max. velocity exported* to 5,000 m/s with option *DeltatV|DeltatV settings|Limit DeltatV velocity exported to maximum 1D-gradient velocity* checked.
- June 23, 2022 : don't enable *DeltatV|DeltatV settings|Limit DeltatV velocity exported to maximum 1D-gradient velocity* for short profiles when resetting *DeltatV settings* to defaults. Disable per default.
- June 22, 2022 : optimize DeltatV interpretation shown in latest tutorial NGU_G1. Add links to archives on DropBox.
- June 21, 2022 : we have added more figures to our latest tutorial NGU_G1 and now show layered refraction interpretation with *Plus-Minus* method in Fig. 10 with RMS error 2.8%/1.7ms.
- June 20, 2022 : added *OK/Cancel/Reset* buttons to ALT+M *model parameters* dialog in depth sections shown with *Depth|Plus-Minus* etc.

- June 20, 2022 : added controls ***limit maximum basement velocity*** and ***Max. basement velocity [m/sec]*** in *Depth|Plus-Minus* and *Depth|Wavefront* sections. Press ALT+M to bring up the *model parameters* dialog.
- June 17, 2022 : use *File|Export header data|Export refractor branches to .BRN* to export branch points for all shots to ASCII .BRN file.
- June 17, 2022 : use *File|Update header data|Update refractor branches from .BRN* to import branch points for all shots from ASCII .BRN file.
- June 16, 2022 : our latest tutorial shows import of NGU model G1 data and update of header data plus pseudo-2D DeltatV inversion.
- June 15, 2022 : new checkbox ***Update branch points with Plus-Minus (Pro only)*** in *Refractor|Midpoint breaks* mapping dialog displayed with ALT+M. With this option checked our Pro version will update branch points in *Refractor|Shot breaks* display once you click button *Map Traces* and next select *Depth|Plus-Minus* or *Depth|Wavefront* layered refraction method.
- June 15, 2022 : added new command ***Mapping|Delete branch points for all shots*** in *Refractor|Shot breaks* display.
- June 14, 2022 : updated text in new short tutorial and included fixed coordinate file G1.SHOTS.COR in archive input_ngu_g1.zip . Use fixed G1.SHOTS.COR instead of bad G1.COORDS.COR with version 4.02 of our software, with *File|Update header data|Update Station Coordinates*.
- June 13, 2022 : reset *Mapping|Gray picked traveltime curves* when user remaps traces to refractors in *Refractor|Midpoint breaks* display with ALT+M.
- June 12, 2022 : fixed .RAR archives referenced from our short tutorial.
- June 10, 2022 : view our short tutorial showing *Automatic DeltatV* inversion with default DeltatV settings of synthetic traveltimes for NGU report 2020_044 Fig. 11 model G1 (leftmost column).
- June 9, 2022 : add new option ***Extrapolate tomogram over 30 stations*** to *DeltatV|DeltatV settings* menu and to *Depth|Depth conversion Settings* menu.
- June 7, 2022 : check new option ***Smooth invert|Smooth inversion Settings|Extrapolate tomogram over 30 stations*** before running *Smooth invert|WET with 1D-gradient initial model* so WET inversion will regard off-end shots with shot points up to 30 station spacings away from first/last profile receiver.
- June 7, 2022 : ask user to confirm warning prompt about velocity artefacts below off-end shot points due to missing receivers when user checks above new option.
- June 4, 2022 : update profile's off-end topography after *File|Update header data|Update Shotpoint coordinates* with *File|Import Data Settings|Extrapolate receiver line coordinates* unchecked.
- June 4, 2022 : for version 4.02 builds export shotpoint-updated station coordinates with *File|Export header data|Export Station Coordinates*. Now *File|Update header data|Update Station Coordinates* with just exported `COORDS.COR` & *File|Update header data|Update Shotpoint coordinates* with previous `SHOTPTS.SHO`.
- June 2, 2022 : we have rebuilt our raywn402.exe base installer with latest help file. This now also installs `SEG2_Update.EXE` into your `C:\RAY32\BIN` folder. See instructions for version 4.01 base installer. After running the base installer next run our custom `rayup402.exe` or `rayup403.exe` installer coded to match the license number in your dongle. See our installation email for instructions.
- June 1, 2022 : ask user to open correct profile with *File|Open Profile* if user selects `.GRD` file in different profile directory than currently opened profile directory with *Grid menu* items.

Version 4.02 released in May 2022 :

- May 30, 2022 : write debug grids & mask grids & WDVS grids to `DEBUG` subdirectory in your currently opened profile database folder instead of writing to `C:\RAY32\DAT` with option *WET Tomo|WET tomography Settings|Write|Write blanked and mask grids and WDVS debug grids* checked.
- May 30, 2022 : ask user to open correct profile with *File|Open Profile* if user selects `.GRD` in different directory than currently opened profile directory with *Grid menu* item ***Export grid file to ASCII .TXT***
- May 30, 2022 : use our *Grid menu* item ***Export grid file to ASCII .TXT*** for WET tomogram .GRD files obtained for currently opened profile database only, to ensure consistent x/y/z coordinates in the exported .TXT file. See our .pdf reference on page 197.
- May 21, 2022 : updated introduction to help chapter *Pseudo-2D DeltatV inversion* in help file.
- May 21, 2022 : test our updated free trial now with latest help file included.
- May 20, 2022 : added paragraph ***Add correct x/y/z coordinates to SEG-2 trace headers*** to help file chapter *Seismic and header data import*. Describe usage of our new SEG2_Update utility.

- May 20, 2022 : updated paragraph ***WDVS velocity smoothing*** in help file chapter *Forward model traveltimes*. Describe new WDVS option.
- May 19, 2022 : added paragraph ***Shear wave picking*** at end of chapter *Picking first breaks* in updated help file. Show how to configure trace processing and display options for easy shear wave picking.
- May 18, 2022 : updated comments on DeltatV inversion in our 3016 tutorial on page 12. As shown in Fig. 4 in our synthetic thrust fault zone tutorial, our pseudo-2D *DeltatV inversion* can image local velocity inversions, with close enough shot and receiver spacing and favorable subsurface geology.
- May 15, 2022 : updated instructions and comments in our Line14_WDVS tutorial.
- May 14, 2022 : O'Sullivan describes Engineering geological investigation of earthquake-induced ground damage and tensile characteristics of loess-colluvium soils, Eastern Hillsborough Valley, Christchurch (Univ. of Canterbury thesis, 2015) correlating SRT profile over fault zone with borehole stratigraphy.
- May 13, 2022 : Mebrahtu describes Failure mechanisms and stability analysis of deep-seated landslides in the northwestern Rift escarpment, Ethiopia (Ruhr-Universität Bochum thesis, 2020) using SRT.
- May 13, 2022 : Himi et al. describe The Use of Geophysical Data in the Evaluation of Landslide Stability, correlating SRT with ERT and lithological log data (Universitat de Barcelona 2022).
- May 13, 2022 : add Fig. 39 and Fig. 40 to 3016 tutorial showing more samples of WDVSTIME.GRD imaging in Surfer. Explain asymmetric shape of WDVS area.
- May 12, 2022 : show multiscale WET with Plus-Minus layered refraction starting model in 3016 tutorial. Show how to obtain Plus-Minus method starting model.
- May 10, 2022 : show multiscale WET in 3016 tutorial for even better resolution of overburden layering and sharper contrast between overburden and basement.
- May 9, 2022 : further expanded text in 3016 tutorial on last few pages.
- May 8, 2022 : add Fig. 29 to 3016 tutorial showing interactive WET using DeltatV starting model : same as Fig. 23 but using WET *wavepath frequency* of 30Hz instead of default 50Hz.
- May 7, 2022 : correctly handle *Cancel* button in file selection dialog shown with *File|Update header data|Update Receiver Coordinates*. Test with 3016 tutorial.
- May 7, 2022 : show DeltatV artefacts warning prompt in 3016 tutorial. Reformat figures.
- May 6, 2022 : show interactive WET inversion using DeltatV starting model in 3016 tutorial with minimal WET smoothing. Use *Ricker wavelet* for back-projection of velocity update across wavepath.
- May 5, 2022 : updated archive 3016_SEG2.zip with fixed .SEG2 files so SEG-2 import works with *File|SEG-2 import settings|Receiver coordinates specified* checked as in Fig. 17 in 3016 tutorial.
- May 5, 2022 : in our updated 3016 tutorial we recommend on last page to update SEG-2 trace header fields SOURCE_LOCATION and RECEIVER_LOCATION with true x/y/z coordinates using SEG2_EDIT utility before importing these SEG-2 files into a profile database. Edit matching _3D.TXT response files with true x/y/z coordinates and then invoke SEG2_EDIT directly or via our SEG2_Update utility via *File, SEG-2 import settings, Update SEG-2 files with coordinates*.
- May 1, 2022 : added two more figures to latest tutorial. Describe how to generate Fig. 19 Surfer plot showing image map of WDVSTIME.GRD in Golden Software Surfer version 23.
- Apr 29, 2022 : added two more figures to latest tutorial. In Fig. 19 we show Surfer plot of WDVSTIME.GRD showing delay time along scan lines from central grid node, using WET grid velocity.
- Apr 28, 2022 : added Fig. 17 to latest tutorial showing how to configure *SEG-2 import settings*. Expanded text comparing Fig. 7 with Fig. 14.
- Apr 27, 2022 : added more figures to latest tutorial and described near-surface layering from borehole drilled at station 101. Added download links for .RAR archives. Updated text and captions.
- Apr 26, 2022 : our latest tutorial shows *Smooth inversion* (discarding *WET smoothing* after forward modeling) for refraction profile recorded over strongly weathered sandstone in Australia
- Apr 25, 2022 : review our updated brochure. We now use up to 32 CPU cores with Pro version for even faster parallelized WET inversion of large data sets recorded with long lines or land/marine streamer.
- Apr 23, 2022 : Burton et al. describe Hydrogeophysical Investigations of Earthen Dams-Two California Case Studies (CSEG Recorder, Dec 2017)
- Apr 23, 2022 : Hunter et al. describe Seismic site characterization with shear wave (SH) reflection and refraction methods (Journal of Seismology 2022)
- Apr 23, 2022 : Hunter et al. describe Shear wave velocity measurement guidelines for Canadian seismic site characterization in soil and rock (Natural Resources Canada 2012)
- Apr 14, 2022 : we recommend disabling Google Chrome software reporting tool for performance and privacy reasons.

- Apr 12, 2022 : Amanti et al. describe Le attività del Servizio Geologico d'Italia (Ispra) a seguito della sequenza sismica del 2016-2017 in Italia Centrale and correlate MASW with SRT and HVSR for seismic microzonation (Geological Survey of Italy).v
- Apr 9, 2022 : more robust SEGY import. Stop scanning shots in current SEGY file once 1000 shots have been scanned.
- Apr 8, 2022 : fixed broken/outdated links to publications listed at https://rayfract.com/modeling.htm
- Apr 7, 2022 : fixed broken/outdated links to publications listed at https://rayfract.com main page
- Apr 7, 2022 : Eulilli et al. describe Integrated geophysical surveys supporting shallow subsurface faults detection and characterization : two case studies in the Central Appennines (6th International INQUA Meeting on Paleoseismology, Active Tectonics and Archaeoseismology, Italy 2015)
- Apr 6, 2022 : Watts et al. published An Assessment of Geophysical Survey Techniques for Characterising the Subsurface Around Glacier Margins, and Recommendations for Future Applications (Frontiers in Earth Science, Feb 2022)
- Apr 3, 2022 : updated comments in our new tutorial on page 7
- Apr 1, 2022 : Samad et al. describe Detection of Soil Pipes using Refraction Seismics (SAGEEP 2022 conference abstract, Denver Colorado Mar 2022)
- Mar 30, 2022 : our Pro version can now use up to 32 CPU cores and OpenMP threads for parallelized *WET inversion* instead of maximum of 16 CPU cores with previous build.
- Mar 26, 2022 : Koley et al. describe Surface and underground seismic characterization at Terziet in Limburg—the Euregio Meuse–Rhine candidate site for Einstein Telescope (Classical and Quantum Gravity, Jan 2022)
- Mar 24, 2022 : tested latest 4.02 Standard build in Windows 11 Pro 21H2 with latest Surfer 23 version Feb 1, 2022. No issues found.
- Mar 22, 2022 : show *Band-Pass* and *High-Pass* frequency filters in our new tutorial (Fig. 26 and 27)
- Mar 21, 2022 : show how to sharpen *WET wavepath coverage plot* in our new tutorial (Fig. 25) and update figure captions and instructions
- Mar 19, 2022 : show alternative interpretation in our new tutorial using *Plus-Minus layered refraction* starting model
- Mar 17, 2022 : write new *DeltatV|DeltatV settings* and new *Model|Forward modeling Settings* to .PAR file with *DeltatV|DeltatV Settings|Write new DeltatV settings to .PAR file* checked.
- Mar 17, 2022 : prompt user to confirm when enabling *DeltatV|DeltatV Settings|Write new DeltatV settings to .PAR file*. Warn that resulting .PAR files are not downward compatible with earlier builds of our software.
- Mar 15, 2022 : view our updated brochure for latest specifications and capabilities
- Mar 14, 2022 : regard option *File|Import Data Settings|Default time unit is seconds* for import of GeoTomCG .3DD files. This option is unchecked when user selects GeomTomCG format in *Import Data* dialog or when user opens existing database with GeoTomCG format selected in this dialog.
- Mar 14, 2022 : show alternative interpretation in our new tutorial using *1D-gradient starting model*
- Mar 12, 2022 : write new WDVS parameters to .PAR file & restore from .PAR file
- Mar 12, 2022 : per default activate WDVS setting *Add nodes once only with overlapping scan lines*
- Mar 11, 2022 : updated text on page https://rayfract.com/pricing.htm to make it more clear that your Standard license is a permanent license and does NOT expire when paid support period expires. See also our Standard licensing agreement.
- Mar 11, 2022 : updated/expanded text in new tutorial and updated figure captions
- Mar 10, 2022 : view our new tutorial showing multiscale WET inversion of our Line14 sample profile made available by our Spanish reseller IGT/Medios Geofísicos S.L. We show improved lateral resolution in basement using multiscale WET inversion and WDVS velocity smoothing.
- Mar 7, 2022 : Soejono et al. show Interdisciplinary geoscientific approach to radioactive waste repository site selection (Journal of Maps, Dec 2021)
- Mar 7, 2022 : Polcino correlates downhole seismic with SRT and MASW (Studio Geologico Dott.ssa Sara Polcino 2008)
- Feb 27, 2022 : Flechsig et al. show Integrated geophysical and geological methods to investigate the inner and outer structures of the Quaternary Mýtina maar (W−Bohemia, Czech Republic) in (International Journal of Earth Sciences, Jan 2015)
- Feb 27, 2022 : Lindvall and Larsson show Combined tunneling site investigations with resistivity and refraction seismic in urban underwater environments (Lund University 2016 thesis)
- Feb 27, 2022 : Cho et al. describe Crossplot Interpretation of Electrical Resistivity and Seismic Velocity Values for Mapping Weak Zones in Levees (The Journal of Engineering Geology, Dec 2021)

- Feb 27, 2022 : Arndt et al. show P- and S-Wave Hybridseismics: Non-Destructive Geotechnical Site Characterizations Using State-Of-Science Surface Geophysics (6th International Conference on Geotechnical and Geophysical Site Characterization, Budapest, Sep 2021)
- Feb 23, 2022 : for easy instructions on how to copy or move files between Windows directories see https://www.howtogeek.com/667029/how-to-copy-or-move-files-and-folders-in-windows-10/
- Feb 23, 2022 : updated our Getting started instructions with above link
- Feb 22, 2022 : with ***Grid|Plot topography on tomogram*** checked edit the polyline colour for topo :
  - go into Surfer 22/23 velocity tomogram plot and check ***View, Contents***
  - in Surfer *Contents tab* click plus symbol left of item Base(Vector)-WAVEMODL.BLN
  - click on bottom-most *Polyline* label
  - in tab *Line properties* at bottom-left change colour from white to e.g. Forest Green or Pink
- Feb 18, 2022 : view our updated Canadian trademark registration
- Feb 15, 2022 : to enable *Model|Forward model traveltimes* command you first need to run our *Smooth invert|WET with 1D-gradient initial model* command and confirm prompts to obtain WET output.
- Feb 14, 2022 : to edit lateral refractor smoothing for *Plus-Minus, Wavefront and CMP intercept-time refraction* methods click *No button* in *WET continuation prompt*. Click on depth section title bar and press ALT+M to show the model parameters dialog. See help chapter ***WET inversion with layered refraction starting model*** on page 245 of our .pdf reference.
- Feb 11, 2022 : *DeltatV|XTV Parameters dialog* settings are not regarded for *DeltatV|Automatic DeltatV and WET inversion*. Instead we use XTV settings obtained by clicking *Gradient model* button in the XTV Parameters dialog, for *Automatic DeltatV* inversion.
- Feb 11, 2022 : *DeltatV|Interactive DeltatV* inversion does regard *DeltatV|XTV Parameters* settings.
- Feb 10, 2022 : Granja-Bruña et al. correlate ERT, SRT, Refraction Microtremor (ReMi), Magnetic Resonance sounding (MRS) and Vertical Electrical Sounding (VES) with sediment cores for infill geometry and reconstruction of former glacial formations (Journal of Applied Geophysics Dec 2021)
- Feb 10, 2022 : Simms et al. correlate ERT with SRT for identification of anomalous zones which could be sand boils along dam (U.S. Army Corps of Engineers/ERDC report Sep 2021)
- Feb 10, 2022 : Di Mauro et al. correlate P-wave velocity obtained with SRT with lithological log obtained from borehole
- Feb 10, 2022 : Ospina and Andrés use SRT and MASW to model velocity and determine lithology on top of salt mine (Univ. de los Andes thesis 2020)
- Feb 10, 2022 : Sandoval uses core drilling, SRT, Scanning Electron Microscopy (SEM) techniques, petrographic tests, X-ray diffraction tests and X-ray fluorescence for qualitative and quantitative description of the micro-macro structure of slates (UPC Barcelona thesis 2021)
- Feb 10, 2022 : Benboudiaf et al. use clustering of P-wave vs. S-wave velocity to differentiate geological layers based on seismic velocity (SEG Geophysics Oct 2021)
- Feb 7, 2022 : added more instructions for configuration of CodeMeter server via WebAdmin running under Windows 10 or 11 in our WebAdmin .pdf on page 3
- Feb 5, 2022 : when specifying a .BLN *blanking file* in *WET Tomo|WET Velocity constraints dialog* you may see a low-velocity artefact/layer below the blanked region with *blanking velocity* of 1,500m/s for water overburden. Specify a *blanking percentage* of 20% in column 4 of the .BLN header line and decrease the blanking velocity in column 3 by 20% to 1,300m/s to avoid this artefact.
- Feb 5, 2022 : updated Fig. 6/7/8 and instructions in WebAdmin .pdf
- Feb 2, 2022 : updated WebAdmin .pdf with Fig. 6/7/8 showing how to configure your router and server PC for public Internet access to CodeMeter server. Add WAN IP address for your router on client PC using WebAdmin (Fig. 4).
- Feb 2, 2022 : new DeltatV setting *Regard 3D source-receiver offset for all traces*. Uncheck to regard 3D source-receiver offset for traces max. 5 station spacings from shot station only. This option is unchecked per default. Checking this option may help with lines which are bent in xy plane.
- Feb 1, 2022 : view our updated 2022 color ad
- Jan 29, 2022 : we now host the CodeMeter 7.30a runtime installer for macOS 10.13 High Sierra.
- Jan 28, 2022 : renamed *interactive DeltatV static* options to *No statics/regard shot offset for all traces* and *No statics/regard shot offset for near traces*. Per default regard shot offset for all traces for determination of weathering velocity used to correct first breaks for shotpoint offsets from line.
- Jan 27, 2022 : added Fig. 5 to CodeMeter client/server configuration guide showing how to display active Rayfract® sessions in WebAdmin Dashboard, License Monitoring, Sessions tab. Updated text.
- Jan 26, 2022 : we now show in our CodeMeter client/server configuration guide ***how to enable remote WebAdmin read access for all clients*** in WebAdmin server configuration in Fig. 3. Without enabling this server option the client/server communication will not work.

- Jan 24, 2022 : updated Configure_CodeMeter_client_and_server_via_WebAdmin.pdf explicitly lists all steps mentioned in figure captions.
- Jan 24, 2022 : here is the current download link for CmAdmin_en.pdf CodeMeter Administrator Guide
- Jan 23, 2022 : new *DeltatV* and *refractor mapping* option *Regard true receiver coordinates for shot offset correction* is listed below option *Regard mapping for shot offset correction*
- Jan 23, 2022 : improved correction of first breaks for offset of shot point (including shot depth) from receiver line and correction for offset of receivers from receiver stations
- Jan 16, 2022 : tested Surfer 23 and CodeMeter 7.40 in Windows 11 21H2 with latest 4.02
- Jan 16, 2022 : redid profile-guided optimization using latest Visual Studio 2019 in Windows 10 21H1
- Jan 15, 2022 : tested latest Golden Software Surfer 23 released Jan 3, 2022 under Windows 7 64-bit Pro and Windows 10 version 21H1.
- Jan 14, 2022 : tested latest CodeMeter version 7.40 under Windows 10 21H1
- Jan 12, 2022 : reset weight of WDVS velocity grid nodes to zero outside WDVS area / with time above one WDVS period. Helps to suppress WDVS artefacts in WET tomograms.
- Jan 12, 2022 : fixed our new WDVS option *add all velocity nodes within WDVS area with radius of one wavelength.* Correctly determine time for velocity grid nodes inside WDVS area (Zelt and Chen 2016).
- Jan 6, 2022 : added radio button *No statics with true offsets incl. shot offsets* to *DeltatV|Interactive DeltatV|Static Corrections* dialog. Source-receiver offset is determined by Cartesian distance in 3D.
- Jan 6, 2022 : renamed former radio button *No static corrections applied* to *No static corrections with offset along topo*. Source-receiver offset is determined by station number difference. For station number difference smaller than or equal to 5 station spacings we use Cartesian distance in 3D instead.
- Jan 5, 2022 : edit the Contour Level method in Surfer Object Manager (named Contents in Surfer 22) :
  - on top of Surfer version 22 window check box *Contents*
  - in *Contents* window at left top left-click on *Contours map symbol*
  - in *Levels* tab set *Level method* to **`Simple`**. This is initialized to **`Advanced`** per default.
- Dec 29, 2021 : increase maximum allowed value for WDVS parameter *Angle increment between scan lines* to 20 degrees from former 10 degrees. A larger increment results in faster WDVS smoothing.
- Dec 27, 2021 : improved accuracy of *Model|WDS smoothing* when checking new option *add all velocity nodes within WDVS area.* Regard all velocity grid nodes on interpolated boundary of WDVS area. Also improved speed of WDVS smoothing with this option checked.
- Dec 27, 2021 : write WDVSMASK.GRD and WDVSTIME.GRD for each 10th velocity grid node to C:\RAY32\DAT with option *WET Tomo|WET tomography Settings|Write|Write blanked and mask grids and WDVS debug grids* checked.
- Dec 22, 2021 : we offer two more options in our *Model|WDVS Smoothing* dialog :
  - check *add all velocity nodes within WDVS area with radius of one wavelength* to determine WDVS velocity as described by (Zelt and Chen 2016). Increase the *WDVS frequency* with this option checked to avoid WET artefacts and too high RMS errors.
  - check *pad wdvs area border with one grid cell* to avoid ragged tomogram bottom
  - these two options are not enabled for our free trial
  - enabling option *add all velocity nodes within WDVS area with radius of one wavelength* will substantially increase the WET runtime especially for small grid cell size.
  - we recommend leaving these new options unchecked for faster WET inversion
  - alternatively check our new WDVS option *add nodes once only with overlapping scan lines for velocity averaging* for a good and much faster approximation of full WDVS smoothing (Zelt and Chen 2016).

- Dec 18, 2021 : for shallow marine refraction surveys with sources located above the receiver spread we assume that shotpoint z in column no. 4 in the SHOTPT.SHO is at same level as the receiver spread, at shot station no. listed in 3rd-last column in the SHOTPTS.SHO obtained via *File|Export header data* :
  - lookup the interpolated shot station coordinates in the COORDS.COR also obtained via *File|Export header data* submenu
  - copy shot station z from COORDS.COR column no. 4 into column no. 4 in the SHOTPTS.SHO
  - set *shot depth* in SHOTPTS.SHO column no. 5 to difference between inline shot station z just copied from COORDS.COR and true source elevation above the receiver spread.
  - this will give you a *negative shot hole depth*

- Dec 18, 2021 : with negative shot hole depths check *WET Tomo|WET tomography Settings|Blank* option *Regard negative shot depth*. Also check option *Don't blank above topography* and specify a *blanking file* in *WET Tomo|WET velocity constraints* as in our SR6 tutorial.
- Dec 17, 2021 : test latest 4.02 free trial with updated *WDVS Smoothing* dialog, see bullet Dec 13, 2021.f

- Dec 16, 2021 : write line entry “Grid disk file name” with .TXT extension to .PAR file for DeltatV .TXT file.
- Dec 13, 2021 : new *Model|WDVS Smoothing* option ***add nodes once only with overlapping scan lines for velocity averaging***. This option can help to suppress WDVS artefacts and to speed up WDVS with small *Angle increment between scan lines*. With this option enabled you need to increase the *WDVS frequency* to prevent too large RMS errors.
- Dec 13, 2021 : increased default *WDVS frequency* from 200Hz to 300Hz.
- Dec 9, 2021 : our KING17 joint hole WET inversion works well with WDVS@250Hz and 100 Steepest-Descent WET iterations. *Discard WET smoothing* after forward modeling. Specify *Manual WET smoothing* with *half-width* 10 & *half-height* 1. Set *Max. velocity* to 3,200m/s. Set *Ricker differentiation* to -2 [Cosine-Squared]. Force *grid cell size* to 0.5m.
- Dec 7, 2021 : new menu item *File|SEG-2 import settings|Update SEG-2 files with coordinates* calls into our new SEG2_Update.EXE app. See below.
- Dec 5, 2021 : install our new SEG2_Update utility into your C:\RAY32 root directory. SEG2_Update.EXE lets you select a SEG-2 .DAT/.SG2/.SEG2 trace file. Next select the output directory. Now click button *Update matching SEG-2 files* to build a .BAT batch file with one line for each matching SEG-2 file (with same extension) for which a matching _3D.TXT file (same name) exists in same directory. Next we call this .BAT file to update your SEG-2 files calling into SEG2_EDIT.EXE utility. See also our tutorial SR6.pdf for details on invocation of SEG2_EDIT.EXE and sample SEG-2 and matching _3D.TXT files with 3D source and receiver coordinates.
- Dec 4, 2021 : here is an archive with the Free Pascal project files including .PAS source for above SEG2_Update. We used Lazarus development environment version 2.2.0RC2 released Oct 31/2021.
- Dec 2, 2021 : when you check option *Model|Model each receiver* for joint WET inversion with borehole profiles added in *Header|Profile* we now regard this option selected for the main/currently opened profile database for all added borehole profiles. For earlier builds you need to check this option for each of the added borehole profiles, after opening the borehole profile with *File|Open Profile*. We tested this with our KING17 joint WET inversion tutorial.
- Nov 30, 2021 : updated help file chapter *Calling Surfer* with more screen shots and improved text. Also updated paragraph ***Import GeoTomCG .3DD trace files*** in chapter *Seismic and header data import*.
- Nov 30, 2021 : how to pick a .BLN blanking file in Surfer 11 : display a WET tomogram with our *Grid menu* item *Image and contour*. Click on Map symbol in Object Manager at top-left. Now select item *Digitize* in *Map menu*. Once you have picked the closed polygon on the tomogram plot select *File menu* item *Save As* at top-left of window with polygon coordinates. Save to .BLN file e.g. digitized.bln .
- Nov 29, 2021 : updated logic for extrapolation of initial refraction method models for ***joint WET inversion*** with borehole profiles added in *Header|Profile*. Our joint WET inversion now works with ***boreholes which are outside the refraction spread*** i.e. laterally offset from first/last refraction receiver.
- Nov 23, 2021 : updated our one-page brochure and flyer showing support for latest Windows 11 and Surfer 22 versions. Advertise automatic mapping of traces to refractors for layered refraction methods.
- Nov 22, 2021 : updated comments and links in our P6 tutorial showing multiple/alternative starting models for WET inversion
- Nov 17, 2021 : retest 4.02 in Visual Studio 2005 with GDIView : no GDI resource leaks
- Nov 13, 2021 : retested 4.02 in Visual Studio 2005 with Heap Agent 10 : no memory leaks/overwrites
- Nov 12, 2021 : retested latest version 4.02 in latest Visual Studio 2019 with address sanitizer enabled
- Nov 11, 2021 : with a current 4.01 or 4.02 installation you need to clear your browser cache and download & run latest rayup402.exe or rayup402pro.exe update installer only. No need to first rerun the base installer raywn401.exe or raywn402.exe. Update help file with winhelp.exe installer.
- Nov 10, 2021 : for easy instructions on how to clear your web browser’s cache see
  - https://www.pcmag.com/how-to/how-to-clear-your-cache-on-any-browser
  - Under Windows use key combination **Ctrl+Shift+Del** in your web browser to bring up dialog to clear browser cache. Under macOSX use key combination **Command+Shift+Delete** .

  We always recommend clearing your web browser’s cache before downloading updated installers as described in our email. Otherwise you may end up with an outdated or even broken installer. We don’t always change the version numbers included in the installer’s filename when updating installers.

- Nov 10, 2021 : we have rebuilt and uploaded an improved raywn402.exe base installer. See our email for instructions on how to install our latest version 4.02 software.
- Nov 10, 2021 : be sure to first clear your web browser cache before downloading our fixed raywn402.exe base installer. Or download and run raywn401.exe base installer. Next run your custom rayup402.exe or rayup402pro.exe update installer as described in our email.

- Nov 5, 2021 : we renewed the SSL certificate for https://rayfract.com . Also we now display the SSL trust logo at bottom of web page.
- Nov 1, 2021 : we now fully support generation of layered refraction starting models for joint WET inversion with borehole line/spread. Tested with our 11REFR tutorial.
- Oct 30, 2021 : updated first page of our 11REFR tutorial and first page of 1611HOLE tutorial
- Oct 30, 2021 : improved robustness of our joint borehole inversion as shown in 11REFR tutorial
- Oct 27, 2021 : *File|Update header data|Update Receiver Coordinates* from .LST file resets receiver station coordinates to averaged coordinates of receivers linked to that station.
- Oct 26, 2021 : don't delete first break picks with *File|Update header data|Update Receiver Coordinates* from .LST file. Use *Update First Breaks* to update first breaks from .LST .
- Oct 26, 2021 : check *File|Export data settings|Export receiver coordinates* before selecting *File|Export header data|Export First Breaks to .LST* to export receiver coordinates instead of station coordinates.
- Oct 26, 2021 : don't reset reset receiver coordinates to linked/updated station coordinates with *File|Update header data|Update Station Coordinates*. Use button ***Reset Receiver Coordinates*** in *Header|Receiver* instead.
- Oct 24, 2021 : more robust import error handling if option ***Allow missing traces*** is unchecked and there are missing channels in input files. Tested with SAPRI12 tutorial and updated free trial.
- Oct 23, 2021 : further improved text and Table of Contents in updated .pdf reference
- Oct 23, 2021 : rebuild free trial installer with latest help file
- Oct 22, 2021 : further updated help file chapters *Introduction*, *Installation*, *WibuKey setup*, *Data processing sequence overview* etc.
- Oct 19, 2021 : we now host WibuKey 6.51 runtime installer from April 2019 on our website. Tested under Windows 7 64-bit Pro up to Windows 11 64-bit Pro.
- Oct 19, 2021 : also we host 32-bit WibuKey 5.20b runtime installer from 2007 on our website. Use with Rayfract® version 3.15 and earlier under Windows XP SP3 32-bit. We do not support these ancient versions from 2009 and earlier any longer.
- Oct 17, 2021 : tested 4.02 Standard with WibuKey runtime 6.51 and 6.60 in Windows 11 Pro 21H2
- Oct 16, 2021 : tested 4.02 Pro in Windows 11 Pro version 21H2 running in Parallels Desktop 17.1.0 VM. Tested with CodeMeter runtime version 7.30a and Surfer 11 free demo. This works just fine.
- Oct 10, 2021 : further updated help file chapters Introduction etc.
- Oct 9, 2021 : Herlambang and Riyanto use WET inversion with Plus-Minus and 1D-gradient starting model and Soil Penetration Test (SPT) for determination of depth of bedrock (IOP 2021).
- Oct 9, 2021 : Amanti et al. use MASW, SRT and HVSR for seismic microzonation (GNGTS 2017).
- Oct 9, 2021 : Awad et al. use ERT, SRT and MASW for dam safety review (GeoVirtual 2020).
- Oct 9, 2021 : Ronning et al. use multirun Conjugate-Gradient WET inversion with Plus-Minus and DeltatV starting model and compare with Geogiga DWTomo refraction inversion and borehole data (NGU Trondheim 2021).
- Oct 7, 2021 : further improved text and formatting in updated .pdf reference
- Oct 5, 2021 : updated .pdf reference re-generated from latest help file version
- Oct 5, 2021 : our 2017 .pdf reference is still available too
- Oct 2, 2021 : updated new documentation shows how to configure CodeMeter client and server
- Sep 29, 2021 : new documentation shows how to configure CodeMeter client and server in WebAdmin running on different PC's connected via WiFi. Ask us for a quote for a network license dongle.
- Sep 26, 2021 : added more screen shots of menus in updated help chapter Commands. Reformatted Bibliography paragraph at end of chapter Introduction.
- Sep 25, 2021 : restored raywn401.exe base installer with 4.01 reference database. This got updated by mistake to include 4.02 reference database in early September 2021. So running raywn401.exe and rayup401.exe update installer resulted in a bad installation with our import routine not working any longer. Running raywn401.exe and rayup402.exe update always worked fine. Now both installation sequences are working again.
- Sep 23, 2021 : updated help popup topic ***Allow missing traces*** in menu *File|Import Data Settings*.
- Sep 20, 2021 : updated help file chapter ***Pseudo-2D DeltatV inversion***. Describe all controls for dialog *DeltatV|Common offset dip estimation*.
- Sep 18, 2021 : tested 4.02 with new Golden Software Surfer version 22.1.151 Sep 7, 2021 build.
- Sep 18, 2021 : added paragraph *Import GeoTomCG .3DD trace files* in updated help chapter ***Seismic and header data import*** . Updated popup help topic ***Station spacing*** shown with F1 in *Header|Profile*.
- Sep 16, 2021 : updated help file chapter ***Seismic and header data import***
- Sep 15, 2021 : updated help file chapter ***WET tomography processing***
- Sep 14, 2021 : further updated help file chapter ***Seismic and header data import***

- Sep 14, 2021 : Nisio et al. show Preliminary study of hidden underground cavities under the Centocelle Park in the Rome urban area (Memorie della Societa Astronomica Italiana 108:353-372, Aug 2021). They nicely correlate ERT with SRT.
- Sep 14, 2021 : Benjumea et al. show Undercover karst imaging using a Fuzzy c-means data clustering approach (Costa Brava, NE Spain; Engineering Geology Volume 293, November 2021).
- Sep 13, 2021 : Ramiro Camacho uses SRT and passive ReMI for Reconstruction of Quaternary paleo-reliefs in the Olduvai Gorge (Tanzania) (Thesis at Universidad Complutense de Madrid, 2016).
- Sep 13, 2021 : review Siart C. (2018) Merging the Views: Highlights on the Fusion of Surface and Subsurface Geodata and Their Potentials for Digital Geoarchaeology. In: Siart C., Forbriger M., Bubenzer O. (eds) Digital Geoarchaeology. Natural Science in Archaeology. Springer, Cham. https://doi.org/10.1007/978-3-319-25316-9_16 .
- Sep 12, 2021 : improved help chapters ***Editing header data*** and ***Seismic and header data import***
- Sep 11, 2021 : updated description of menu ***More import Settings*** in chapter ***Commands*** in help file
- Sep 10, 2021 : updated section ***Release history*** in help file chapter ***Introduction*** with release notes for version 4.02. Rebuilt free trial installer with latest help file.
- Sep 8, 2021 : added paragraph *Export Surfer grid to ASCII* at end of chapter ***WET tomography processing*** in updated help file.
- Sep 8, 2021 : improved description of *Beydoun weighting* in help chapter ***Crosshole survey interpretation***. Added more references at end of chapter ***Introduction***.
- Sep 7, 2021 : Yang et al. describe First-arrival traveltime inversion of seismic diving waves observed on undulant surface. They apply gradient layer stripping equations described by Gibson et al. 1979 and used with our DeltatV method and estimate source and receiver specific velocity gradients to account for strongly undulating topography (GJI 2021). Shi et al. describe the same layer stripping method for 3D refraction interpretation (Journal of Earth Science 2015).
- Sep 3, 2021 : tested version 4.02 calling Surfer 21 July 2021 update/version 21.2.192 64-bit under Windows 10 64-bit Pro version 21H1.
- Aug 30, 2021 : further updated help file chapter ***Smooth inversion***.
- Aug 27, 2021 : further updated help file chapter ***Commands*** and other chapters.
- Aug 24, 2021 : further updated help file chapter ***Commands*** and chapter ***Mapping traces to refractors***.
- Aug 22, 2021 : updated ***File menu*** description in help chapter ***Commands*** in updated help file.
- Aug 19, 2021 : add shortcut descriptions for controls in chapter ***Filtering traces*** in updated help file.
- Aug 18, 2021 : add shortcut descriptions for ***DeltatV*** controls in updated help file.
- Aug 18, 2021 : improved shortcut descriptions of ***WET*** controls in updated help file.
- Aug 14, 2021 : added more short descriptions of ***WET*** controls in updated help file.
- Aug 14, 2021 : Raul et al. show multi-method geophysical investigation on a very large, slow-moving landslide (EAGE First Break, Aug 2021 issue).
- Aug 14, 2021 : updated one-page brochure and flyer .
- Aug 11, 2021 : our free trial now allows automatic first break picking and polyline guided picking.
- Aug 11, 2021 : update your current version 4.02 installation with our updated help file.
- Aug 10, 2021 : we now offer our ***trigger jitter removal*** dialog and menu items also for our Standard license and free trial, not just with our Pro license.
- Aug 10, 2021 : added button ***Backup times*** to *trigger jitter removal* dialog. Click to backup station coordinates, shot point coordinates including trigger delay and delay time and first breaks to **`COORDS.COR`**, **`SHOTPTS.SHO`** and **`BREAKS.LST`** in **`Backup`** subdirectory of currently opened profile.
- Aug 8, 2021 : prompt user to confirm activation of option ***Model|Model each receiver not receiver stations*** . Ask user to ensure correct receiver coordinates in *Header|Receiver* dialog.
- Aug 8, 2021 : added button ***Reset receiver coordinates*** in *Header|Receiver* dialog to reset coordinates for all receivers to their linked receiver stations.
- Aug 7, 2021 : added more options to ***Edit trigger jitter removal*** dialog in *Processing menu* shown with *Trace|Shot gather* opened. This dialog is available with our Pro version only.
- Aug 5, 2021 : review The Effect of Aspect and Elevation on Critical Zone Architecture in the Reynolds Creek Critical Zone Observatory: A Seismic Refraction Study (Travis Nielson et al. Front. Water, 19 July 2021)
- Aug 2, 2021 : tested version 4.02 of our software with Microsoft Windows 10 May 2021 21H1 update
- Aug 2, 2021 : rebuilt version 4.02 with Visual Studio 2019 Version 16.10.4 for improved conformance with Windows 10 Pro 64-bit
- July 31, 2021 : added popup help topics for all controls in *WET Tomo|Coverage plot setup* dialog. Updated paragraph on ***WDVS Smoothing*** in chapter *Forward model traveltimes*. Use our updated help installer to update your installation of our software.

- July 31, 2021 : updated Test21 tutorial with *WDVS Smoothing settings* recommendations
- July 31, 2021 : updated mdw2011 crosshole survey tutorial describes how to
  - determine station numbers for ***Shot pos.*** and ***Layout start*** for *Line type* **`Borehole spread/line`**
  - how to generate, edit and apply COORDS.COR and SHOTPTS.SHO files once you imported your SEG-2 shots into the profile
  - see also our .pdf reference chapter ***Crosshole survey interpretation*** on page 113 and following
- July 30, 2021 : Ross et al. show Seismic refraction investigation of the Strengbach watershed (Vosges Mountains, France) using P and S-wave first-arrival tomography (EOST at Univ. Strasbourg 2017).
- July 29, 2021 : Fabien-Ouellet shows an integrated approach to shallow seismic interpretation in his 2014 thesis (Univ. Laval). Also see https://gfabieno.github.io/bib/Fabien-Ouellet-2014.pdf .
- July 24, 2021 : Jaramillo Lopez shows correlation between geomechanical properties, number of blows and geophysical data (Thesis Jaramillo Lopez, Universidad Politécnica Salesiana Sede Quito, 2021)
- July 24, 2021 : added references section to our latest tutorial D1P2NO24.pdf
- July 23, 2021 : added more figures to latest tutorial D1P2NO24.pdf and updated text. Enable WDVS@600Hz and sharpen wavepath coverage plot to visualize low-velocity region.
- July 21, 2021 : our latest tutorial shows improved imaging of constructed low-velocity zones in Stillwater model dam (Thesis Leti Wodajo Univ. of Mississippi 2018)
- July 15, 2021 : updated instructions in Sapri12 tutorial showing SeisImager PlotRefa .VS import
- July 14, 2021 : renamed option in ***Modeling\|WDVS Smoothing*** dialog to easier to understand text ***restore WET smoothing and discard WDVS smoothing only*** .
- July 13, 2021 : allow toggling import option ***File\|Import Data\|Reverted spread layout*** for all import data types. This option is regarded if option ***Turn around spread during import*** is checked only.
- July 7, 2021 : view new .pdf explaining how to download seismic data files and header files needed for our tutorials. Also we give recommendations on how to learn about Rayfract® functionality.
- July 5, 2021 : Dr. Hector Hinojosa shows using body wave SRT for geotechnical engineering in Karst terrains (Linkedin Nov 2020). Shows usage of Poisson's Ratio plots to detect water-saturated zones at top-of-bedrock.
- July 4, 2021 : review new documentation showing installation of CodeMeter runtime and generation of license request file and import of license update file.
- July 4, 2021 : updated text in our new Test21 tutorial . vUse our our updated free trial for this tutorial.
- July 3, 2021 : Parsa Bakhtiari Rad compares near-surface reflection with SRT for imaging of soft soil subsurface (SAGEEP 2021; Univ. of Mississippi)
- June 30, 2021 : we now prompt to check ***Smooth invert\|Smooth inversion Settings\|No shot position checking*** if shot points apparently are not located at traveltime curve minimum during WET inversion.
- June 30, 2021 : we now support importing **`Geogiga DWTomo .TTX`** traveltime files with recording geometry via our ***File\|Import Data*** dialog. Test this with our updated free trial. Email us your .TTX if you encounter any issues.
- June 26, 2021 : added Fig. 22 to Test21 tutorial showing selection of DMT .SEG2 files during import
- June 25, 2021 : show peudo-2D DeltatV starting model in our Test21 tutorial
- June 23, 2021 : our new tutorial shows imaging of a highly weathered granitic basement in Australia with thick overburden. Also we show import of DMT SUMMIT X .SEG2 files.
- June 22, 2021 : added SEG-2 import option ***File\|SEG-2 import settings\|Set SEG-2 import settings for DMT SUMMIT X .SEG2 import***. Test this with our updated free trial.

Version 4.01 released in June 2021 :

- June 19, 2021 : check ***File\|SEG-2 import settings\|Ignore SEG-2 station numbers in trace headers*** to determine source and receiver locations from SEG-2 trace header entries SOURCE_LOCATION and RECEIVER_LOCATION. Use for import of DMT SUMMIT X .SEG2 files.
- June 19, 2021 : to import DMT SUMMIT X .SEG2 files check *File\|SEG-2 import settings* options
  - ***Receiver Coordinates specified***
  - ***Ignore SEG-2 station numbers .***

  Next select *File\|Import Data* and
  - click on ***Select*** button
  - navigate into your input directory or directory where you copied the .SEG2 trace files
  - set ***Files of type*** drop box to **DMT (*.SEG2)** entry
  - select one of your .SEG2 files and click *Open* button

- click ***Import shots*** button. Click *Read* button to import each shot displayed.

- June 19, 2021 : don't show outdated SEG-2 import options to determine trace data start any longer.
- June 18, 2021 : fixed joint inversion with *Borehole lines* added to main profile in *Header|Profile* when main profile has fewer receiver stations than in added borehole lines.
- June 17, 2021 : recompiled our app with latest Microsoft Visual Studio 2019 version 16.10.2 for improved performance and improved compatibility with Microsoft Windows 10 64-bit Pro
- June 17, 2021 : prompt to check ***File|Import Data Settings|Allow shot inline offset from shot station larger than two spacings*** if required when importing shots with *File|Import Data* or with *File|Update header data|Update Shotpoint coordinates*.
- June 16, 2021 : updated method to compute receiver inline offset from receiver station
- June 16, 2021 : match GeoTomCG .3DD traces to selected *Default spread type* channels and prompt to import matched traces only if the spread type is too short / has too few channels.
- June 11, 2021 : improved GeoTomCG .3DD import with irregular receiver spacing. Prompt to select *Default spread type* with more channels or increase *Station spacing* if appropriate.
- June 9, 2021 : check ***Model|Forward modeling Settings|Model each receiver not receiver stations*** to forward model at each receiver's location and not at averaged receiver station locations. This can improve the accuracy of WET inversion with irregular receiver spacing but will slow down WET and requires more RAM memory for caching of modeled receiver grids.
- June 5, 2021 : Hartl et al. show tunnel based SRT (University of Leoben, Austria 2019)
- May 30, 2021 : updated Conclusions paragraph in Aaknes-1 tutorial
- May 20, 2021 : updated help file chapter *Picking first breaks* with paragraph on new dialog *Trace|Export reciprocal errors*. This dialog is enabled for our free trial as well.
- May 20, 2021 : our latest software version 4.01 works fine with latest Golden Software Surfer 21.
- May 16, 2021 : Andrea Gomez Casalta compares separate ERT & SRT interpretation with RES2DINV® and Rayfract® with joint inversion using Zond Software ERT & SRT and correlates results with borehole data (Thesis Andrea Gomez Casalta, Institut Cartografic i Geologic de Catalunya 2019).
- May 8, 2021 : write additional columns to .ERR file with shot and receiver station numbers for matched reciprocal trace pairs.
- May 6, 2021 : separate words in .ERR file column headers with underscore '_' characters instead of space characters for easier import into Microsoft Excel spreadsheet
- May 5, 2021 : our new dialog *Model|Export reciprocal errors* lets you specify and generate an ASCII .ERR file with columns listing absolute reciprocal error, relative reciprocal error (Jim Whiteley 2020) and forward shot&channel and reverse shot&channel used to computer these reciprocal errors. Sort this .ERR file in MS Excel by any column to identify bad shots or receivers. .ERR lines are sorted by offset (m) and CMP station as in our *Trace|Offset gather* display. Any trace pair with relative reciprocal picking error above 5 percent or absolute error exceeding 5ms or 10ms needs to be repicked.
- May 4, 2021 : updated free trial installer allows exporting reciprocal errors (see above bullet) and WDVS smoothing. We now enable *Trace|Offset gather* and *Refractor|Offset breaks* for free trial.
- Apr 28, 2021 : view our EGU 2021 abstract entitled Improved interpretation of SAGEEP 2011 blind refraction data using Frequency-Dependent Traveltime Tomography.
- Apr 24, 2021 : Koley S. describes in detail both theory and application of DeltatV and WET inversion to characterize a dipping fault zone (Koley, Vrije Univ. Amsterdam, 2020), correlated with borehole drilling information.
- Apr 22, 2021 : check *DeltatV|Common-offset dip estimation|Reject true velocity lower than overburden velocity* and redo *DeltatV inversion* to prevent too slow DeltatV velocity sections e.g. with our THRUST tutorial.
- Apr 21, 2021 : in the special case where both option *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* and option *Model|WDVS Smoothing|Discard WET smoothing* are checked our *WET inversion* now works correctly. For older builds uncheck *Output inversion results in Feet*, redo the WET inversion in meters and then convert your …\VELOIT20.GRD into feet with *Grid menu*.
- Apr 19, 2021 : updated help file chapter *Pseudo-2D DeltatV inversion* with paragraph on new dialog *DeltatV|Common-offset dip estimation*. This dialog is enabled for our Pro software version only.
- Apr 19, 2021 : updated help file chapter *Installation and licensing* recommends installing CodeMeter runtime version 6.90b in Windows 7 64-bit Pro virtual machine running in Parallels Desktop on macOS instead of installing latest CodeMeter version 7.20 which crashes in Windows 7 64-bit virtual machine.
- Apr 17, 2021 : we now share our SAGEEP2021 WDVS presentation annotated slides on YouTube.

- Apr 16, 2021 : download CodeMeterRuntime.exe version 6.90 installer for Windows 7 64-bit Pro compatibility when running under Parallels Desktop version 16 on macOS. The latest CodeMeter runtime version 7.20 crashes after installation in Windows 7 64-bit Pro running under Parallels.
- Apr 10, 2021 : new dialog *DeltatV|Common-offset dip estimation* lets you edit parameters for ***estimation of dip of common-offset sorted traveltime curves***, and for ***better estimation of true refractor velocity based on apparent CMP velocity and this estimated offset curve dip during DeltatV inversion*** in case of strong refractor dip (Gebrande and Miller 1985; Gebrande 1986). This dialog is available with our Pro version only and is disabled for our Standard software version.
- Apr 10, 2021 : we now flip refractors when imaging a turned-around .GRD tomogram in *Grid menu*.
- Apr 9, 2021 : Barbero and Naldi (2018) show good match between MASW, SRT and ERT in landslide area.
- Mar 30, 2021 : average first breaks in *Refractor|Offset breaks* for adjacent traces with CMP position difference smaller than 0.5 station numbers. This results in a more regular display.
- Mar 29, 2021 : Alvaro Polin Tornero shows synthetic modeling of cavity in dam in his thesis (Univ. Uppsala 2018). View synthetic modeling of air-filled cavity (Parsa Bakhtiari Rad, NCPA 2021) using our *WDVS-enabled WET inversion* in latest version 4.01 of our software released in March 2021.
- Mar 29, 2021 : updated free trial installer allows WDVS smoothing, can call into Surfer 9 to 21 Beta and comes with latest help file.
- Mar 26, 2021 : updated OT0608 tutorial with runtime info using our Pro version on 2020 macMini.
- Mar 26, 2021 : version 4.01 completes 10 WET runs for 1_1D tutorial in 90 seconds on 2020 macMini with 3.0 GHz Intel Core i5 processor using all 6 cores in native Windows 10 64-bit Pro installation via Boot Camp Assistant using our Pro version. This takes 2 minutes using 4 cores in Parallels Desktop 14 on the same 2020 macMini and 3 minutes on 2017 iMac with 2.3 GHz Intel Core i5 processor using 4 cores, in Windows 7 64-bit Pro virtual machine running under Parallels Desktop 16.
- Mar 24, 2021 : added Conclusions paragraph to Aaknes-1 tutorial
- Mar 22, 2021 : view our SAGEEP 2021 expanded abstract demonstrating our new WDVS option
- Mar 21, 2021 : updated help file chapter *Forward model traveltimes* with section on *Model|Create Checkerboard grid dialog*. Updated references in chapter *Introduction*.
- Mar 19, 2021 : updated *Model|Create Checkerboard grid* lets you edit the *Anomaly magnitude* in percent of the background velocity (Zelt Geophys. J. Int. 1998). Each anomaly (checker) is determined by multiplying this percentage with local grid velocity and weighting with sin(x offset)sin(y offset) functional and then adding this velocity delta to or subtracting from local grid velocity in a checker pattern. This dialog is available with our Pro version only.
- Mar 19, 2021 : our SAGEEP 2021 presentation slides are now available.
- Mar 17, 2021 : updated *DeltatV* help popup topics and *Pseudo-2D DeltatV* chapter in help file.
- Mar 15, 2021 : improved accuracy of SEG-2 import for marine refraction surveys with towed hydrophone streamer.
- Mar 13, 2021 : fixed *Smooth invert|WET with 1D-gradient initial model* when enabling AWE for our Pro version with *WET Tomo|WET tomography Settings|Enable AWE physical memory page caching* and checking option *Cache AWE receiver grids in local memory*
- Mar 13, 2021 : we rebuilt and extensively tested our software with latest MSVC Address Sanitizer.
- Mar 11, 2021 : updated help topics *Conjugate Gradient* in *WET Tomo main* dialog and *Damping* in *Edit velocity smoothing* dialog in help file.
- Mar 9, 2021 : run Ray336_Scripts.exe on PC where you installed our version 3.36 or 4.01 software. The updated scripts in `C:\RAY32\DAT` folder work with Surfer 9 to 21 Beta.
- Mar 9, 2021 : updated `AUTOTOMO.BAS` Surfer script to setup the color scale for velocity tomogram with *Min. velocity* and *Max. velocity* limits if *Adapt color scale* checked in *Grid|Surfer plot Limits*.
- Mar 9, 2021 : updated `AUTOTOMO.BAS` Surfer script to set the contour map velocity interval for velocity tomogram to *Velocity interval* if *Adapt color scale* checked in *Grid|Surfer plot Limits*.
- Mar 8, 2021 : show WET output using *WDVS frequency* of 200Hz and 300Hz in PALMFIG4 tutorial.
- Mar 7, 2021 : view our latest PALMFIG4 tutorial showing WDVS-enabled *WET inversion* of Dr. Derecke Palmer 1980 Fig. 4 synthetic data. We fixed the shot positions to obtain lower RMS error.
- Mar 6, 2021 : allow *WET inversion* and forward modeling with just two shots in profile instead of 3.
- Mar 3, 2021 : updated help chapter ***Filtering traces*** describes new ***Trace|Shot gather|Processing|Edit Trigger Jitter Removal*** dialog fields. This dialog is available with our Pro software version only.
- Mar 1, 2021 : view synthetic modeling of air-filled cavity (Parsa Bakhtiari Rad, NCPA 2021) using our *WDVS-enabled WET inversion*. Travel times were forward-modeled with WDVS enabled at 200Hz.

- Mar 1, 2021 : we show *WDVS-enabled WET inversion* with pseudo-2D DeltatV starting model in our updated SR6 marine refraction tutorial. We discard WET smoothing after forward modeling for higher resolution. Also we show ***trigger jitter removal*** to decrease the RMS error and increase resolution.
- Feb 27, 2021 : check *Model|WDVS Smoothing|use WDVS for forward modeling* to better remove artefacts from pseudo-2D DeltatV starting model with *DeltatV|Automatic DeltatV and WET inversion*. Tune *WDVS frequency* as described in help file chapter *Forward model traveltimes*.
- Feb 27, 2021 : *Grid|Reset DeltatV and WET settings to .PAR file* now also restores WDVS settings stored in .PAR file. With older .PAR files without WDVS settings we leave WDVS at current settings.
- Feb 27, 2021 : we store WDVS settings to .PAR file when writing .PAR files during WET inversion.
- Feb 25, 2021 : we have updated our OT0608 tutorial showing layered refraction interpretation with Wavefront method in Fig. 25.
- Feb 25, 2021 : updated free trial installer allows WDVS smoothing, can call into Surfer 9 to 21 Beta and comes with latest help file.
- Feb 23, 2021 : view our SAGEEP 2021 presentation in session Seismic Body Waves Methods II
- Feb 21, 2021 : don't discard WET smoothing in *Model|WDVS Smoothing* with *Conjugate-Gradient* search method specified in *WET Tomo|Interactive WET*, to ensure that WET inversion converges.
- Feb 21, 2021 : use default *Steepest-Descent* search method in *WET Tomo|Interactive WET* when enabling WDVS smoothing in *Model|WDVS Smoothing* dialog, for more robust WET inversion. Use default full WET smoothing or minimal WET smoothing, in *Edit velocity smoothing* dialog.
- Feb 20, 2021 : use more descriptive names for controls in *Model|WDVS Smoothing* dialog. Add radio button *discard WDVS smoothing only and restore WET smoothing*. Update help file chapter *Forward model traveltimes* with help on updated WDVS Smoothing dialog.
- Feb 17, 2021 : we have updated our OT0608 tutorial with traveltime curve displays on last page. Note the high degree of consistency of first break picks and good fit with modeled times.
- Feb 17, 2021 : we now also show traveltime curve displays in our Aaknes-1 tutorial on last page. Note the inconsistent first break picks compared to above OT0608 tutorial.
- Feb 16, 2021 : updated help chapter ***Forward modeling*** showing new ***Model|WDVS Smoothing*** dialog fields.
- Feb 16, 2021 : we moved *Model|Fast WDVS* option into *Model|WDVS Smoothing* dialog. We will copy your current setting of *Model|Fast WDVS* option into your *Model|WDVS Smoothing* dialog when you open an existing profile database.
- Feb 11, 2021 : we show WDVS-enabled WET inversion with default 1D-gradient starting model in our updated OT0608 tutorial. We discard WET smoothing after forward modeling for higher resolution.
- Feb 11, 2021 : we describe the geological setting in updated RJJ9TO10 tutorial
- Feb 11, 2021 : allow *WET wavepath frequency* and *WDVS frequency* range 0.01Hz to 10'000Hz
- Feb 9, 2021 : view our latest GSA Today color ad in Feb 2021 issue
- Feb 8, 2021 : option *WDVS Smoothing|discard WET smoothing after forward modeling* can help to improve the WET resolution if the starting model is close to the final/true model already e.g. for lines OT0608 and GEOXMERC with homogeneous overburden. Use WDVS frequency of 100Hz and wavepath width of 8 percent. But in other situations such as for Broad Epikarst model we recommend not discarding WET smoothing to avoid engraving of the wavepaths into the WET tomogram.
- Feb 7, 2021 : Oyan 2019 shows determination of rock mass anisotropy and lists detailed processing steps including data import and calling into Surfer and Voxler
- Feb 6, 2021 : Chen and Zelt 2017 show Comparison of Full Wavefield Synthetics with Frequency-Dependent Traveltimes Calculated Using Wavelength-Dependent Velocity Smoothing
- Feb 6, 2021 : option *WDVS Smoothing|discard WET smoothing after forward modeling* can help to improve the WET resolution for crosshole surveys such as IGTA13. Use WDVS frequency of 125Hz and force cell size to 0.5m. Leave wavepath width at default 1.6 percent.
- Feb 4, 2021 : added box ***discard WET smoothing after forward modeling*** in ***Model|WDVS Smoothing*** dialog. With this box checked we restore the unsmoothed WET velocity grid after forward modeling during WET inversion, discarding the WDVS smoothed grid at this time (Zelt and Chen 2016).
- Feb 2, 2021 : Chen et al. 2017 show detection of a known near-surface target through application of frequency-dependent traveltime tomography (FDTT) and full-waveform inversion to P- and SH-wave seismic refraction data. Our combination of WET inversion with WDVS smoothing can be considered as a form of FDTT.
- Jan 29, 2021 : we now can offer ***network licenses*** to our software. Share your USB dongle license between multiple PC's connected to the same WiFi network. The user limit is one per dongle per default but can be increased to two or higher. Ask us for a quote. You may also share a network license via VPN. You may need to add a NAT address translation rule on your router.

- Jan 24, 2021 : view the Olson Engineering refraction webinar on YouTube showing field usage of our software with a theoretical background.
- Jan 21, 2021 : Davarpanah et al. 2020 obtain dynamic modulus of elasticity (Young's modulus) directly from P-wave velocity, S-wave velocity and density rho in equation (1). Density rho can be estimated from P-wave velocity with Gardner's relationship rho = 0.23 $Vp^{0.25}$.
- Jan 19, 2021 : updated Surfer **.BAS** scripts to work with Surfer 21 Beta. Run Ray336_Scripts.exe on PC where you installed our version 3.36 or 4.01 software. These updated scripts in **C:\RAY32\DAT** folder work with Surfer 9 to 21 Beta.
- Jan 19, 2021 : more robust Surfer version handling in Surfer **.BAS** scripts
- Jan 16, 2021 : updated CAMP1 tutorial with description of geological setting on last page
- Jan 14, 2021 : our earlier POISSON tutorial shows imaging of Poisson's ratio based on P-wave and S-wave velocity. Pick S-wave shots in *Trace|Shot point gather* with pairs of shots with opposite trace polarity recorded at same shot point.
- Jan 14, 2021 : Enrione and Naldi 2014 compare SRT and MASW for same profile
- Jan 12, 2021 : Terzic et al. 2017 show seismic hazard analysis for dam site with adjacent fault zone
- Jan 6, 2021 : updated RJJ9TO10 tutorial with WDVS-enabled WET inversion using Plus-Minus method layered refraction starting model and using default 1D-gradient starting model.
- Jan 3, 2021 : view our updated color ad
- Jan 3, 2021 : tested our latest version 4.01 under Windows 10 64-bit Oct 2020 update
- Jan 1, 2021 : updated free trial installer comes with latest help file and works with Surfer 9 to 20 Beta
- Dec 30, 2020 : skip plotting refractors on tomogram if …**\LAYRTOMO\PLUSMODL.CSV** layer model .CSV file is missing. To install updated **.BAS** Surfer scripts download & run Ray336_Scripts.exe on PC where you installed our version 3.36 or 4.01 software. These scripts work with Surfer 9 to 20 Beta.
- Dec 28, 2020 : updated SAGEEP11_16 tutorial with more figures and sections Conclusions & References. Added more download links to .RAR archives with profile database & Surfer files.
- Dec 26, 2020 : updated SAGEEP11_16 tutorial with Fig. 28 to 32 demonstrating the improvement in WET tomogram resolution when decreasing the *WDVS frequency* compared with Fig. 24
- Dec 25, 2020 : updated SAGEEP11_16 tutorial comparing Conjugate-Gradient multiscale WET inversion using WDVS and minimized WET smoothing vs. same WET inversion without WDVS
- Dec 24, 2020 : review our updated black-and-white ad
- Dec 23, 2020 : updated free trial installer comes with latest help file and works with Surfer 9 to 19
- Dec 20, 2020 : updated help file chapters *Introduction* and *Forward model traveltimes*. Updated description of *WDVS parameters* and how to tune them for your current profile. Refer to tutorials.
- Dec 19, 2020 : updated Aaknes-1 tutorial with instructions on how to vary *WDVS frequency* and WDVS parameter *Regard nth node* on last page.
- Dec 17, 2020 : updated Aaknes-1 tutorial comparing WET inversion using WDVS and minimal WET smoothing vs. WET inversion without WDVS and using full WET smoothing.
- Dec 11, 2020 : updated CAMP1 tutorial comparing WET inversion with and without WDVS using same WET inversion settings with minimized WET smoothing in Fig. 10a and Fig. 10b.
- Dec 9, 2020 : updated NORCAL14 tutorial with WET+WDVS using minimized WET smoothing. Show WET with 1D-gradient starting model from 2014 with WDVS. Disable WDVS and compare.
- Dec 8, 2020 : updated NORCAL14 tutorial with WDVS-enabled WET inversion using Plus-Minus method layered refraction starting model.
- Dec 7, 2020 : updated EPIKINV tutorial with WDVS-enabled WET inversion using Plus-Minus method starting model. We also show 100 Steepest-Descent WET iterations without WDVS.
- Dec 6, 2020 : updated JENNY13 tutorial with WDVS-enabled Automatic WET using Plus-Minus starting model. Added heuristics for tuning WET and WDVS parameters on last page.
- Dec 5, 2020 : updated JENNY13 tutorial shows WDVS-enabled Smooth inversion and compares with 2013 interpretation without WDVS. Enabling WDVS gives sharper image of basement top.
- Dec 1, 2020 : our website uses secure https transfer protocol showing the lock symbol in address bar
- Nov 27, 2020 : decreased default *WDVS frequency* from 300Hz to 200Hz
- Nov 24, 2020 : download CodeMeterRuntime.exe version 6.90 installer for Windows 7 compatibility
- Nov 23, 2020 : updated CAMP1 tutorial shows WDVS enabled WET with 1D-gradient & Plus-Minus layered refraction starting models. Enabling WDVS dramatically improves WET resolution.
- Nov 17, 2020 : added WET blanking option *Pad boundary polygon for borehole tomogram blanking*
- Nov 15, 2020 : updated free trial installer comes with latest help file and works with Surfer 9 to 19
- Nov 15, 2020 : disable WDVS per default when user opens an old profile with *File|Open Profile*…

- Nov 15, 2020 : pad blanking polygon when user selects *WET Tomo|WET tomography Settings|Blank|Blank outside borehole tomogram*. Alternatively blank via *WET Tomo|WET Velocity constraints* using your own blanking file.
- Nov 12, 2020 : new option *Model|Fast WDVS Smoothing*. Check for faster but less accurate WDVS smoothing. Was enabled per default before Nov 10, 2020. See bullet for Nov 10, 2020.
- Nov 11 2020 : disable WDVS per default when user creates new profile with *File|New Profile…*
- Nov 11, 2020 : when user forces *grid cell size* increase row and column count by one if required so all shot point and receiver symbols are plotted in Surfer on tomogram. Test with IGTA13 tutorial.
- Nov 11, 2020 : increased default *WDVS frequency* from 200Hz to 300Hz
- Nov 11, 2020 : increased default *WDVS angle increment* from 4 degrees to 7 degrees
- Nov 11, 2020 : increased default *WDVS Regard nth node* from 2 to 3
- Nov 10, 2020 : more accurately map scan line nodes to velocity grid nodes during WDVS smoothing
- Nov 8, 2020 : expanded our EPIKINV tutorial with more figures, links and comments
- Nov 6, 2020 : we updated our EPIKINV tutorial (Sheehan et al. 2005) showing WET output obtained with WDVS (Zelt and Chen 2016) enabled. See Zelt, C. A. and J. Chen, Frequency-dependent traveltime tomography for near-surface seismic refraction data, Geophys. J. Int., 207, 72-88, 2016 .
- Nov 5, 2020 : added paragraph *WDVS velocity smoothing* to help chapter *Forward model traveltimes*.
  Nov 4, 2020 : updated base install .pdf showing how to run our raywn401.exe base installer
- Nov 3, 2020 : fixed download links for .RAR archives in SR6 tutorial
- Oct 31, 2020 : updated 11REFR tutorial shows WET with WDVS enabled and minimized smoothing.
- Oct 28, 2020 : check *WET Tomo|WET tomography Settings|Write|Write blanked and mask grids and WDVS debug grids* to write WDVSTIME.GRD and WDVSVELO.GRD to C:\RAY32\DAT with WDVS smoothing enabled in *Model|WDVS Smoothing* dialog.
- Oct 28, 2020 : our updated free trial now allows editing *Model|WDVS Smoothing*. See next bullet.
- Oct 26, 2020 : new dialog ***Model|WDVS Smoothing…*** lets you edit parameters for Wavelength-Dependent Velocity Smoothing (Zelt and Chen 2016). You can edit these WDVS parameters :
  - ***Use WDVS for forward modeling of traveltimes***. If checked we do WDVS velocity smoothing before running our Eikonal solver to forward-model traveltimes over current velocity grid.
  - ***WDVS frequency*** in Hz (1Hz to 10'000 Hz). Used to determine the duration of one wavelength i.e. one period in time. Is set to 200Hz per default. Should be two to four or eight times the ***Wavepath frequency*** specified in *WET Tomo|Interactive WET tomography…* . See (Zelt and Chen 2016). Increase to decrease WDVS smoothing and to speed up WDVS.
  - ***Angle increment*** in degrees (values 1 to 10). This determines the angular separation between straight scan lines radiating outwards from the current grid node when determining the WDVS averaged velocity at that node. Increase this parameter to speed up WDVS. Default is 4 degrees.
  - ***Regard nth node*** (values 1 to 5). Regard each nth node along current angle and scan line when determining WDVS velocity at current grid node via weighted average. Increase to speed up WDVS. Default is 2.

- Oct 24, 2020 : use multiple CPU cores in parallel for WDVS velocity smoothing.
- Oct 21, 2020 : new option ***WET Tomo|WET tomography Settings|Wavelength-dependent velocity smoothing***. See Zelt & Chen 2016 paper. Tested with lines ZONDDATA and LINE14 and TRA9002.
- Oct 16, 2020 : new base install .pdf showing how to run our raywn401.exe base installer
- Oct 15, 2020 : updated free trial installer comes with latest help file and works with Surfer 9 to 19
- Oct 15, 2020 : show traveltime misfit prompt asking you to improve your first break picks in help file chapters *Smooth inversion* and *WET Tomography Processing*. Refer to slope1.pdf tutorial showing how to identify traces with inconsistent picks regarding reciprocity principle in *Trace|Offset gather* display.
- Oct 13, 2020 : in http://rayfract.com/samples/SAGEEP2011shootout.pdf Prof. Bob Whiteley compares the GRM interpretation (Stoyer, 2012) of the SAGEEP2011 blind refraction session synthetic data with our published blind WET interpretation (Rohdewald, 2011) and the true model (Zelt et al. 2013).
- Oct 8, 2020 : review Mebrahtu et al. Tectonic conditioning revealed by seismic refraction facilitates deep-seated landslides in the western escarpment of the Main Ethiopian Rift (Geomorphology 2020)
- Oct 6, 2020 : updated help file chapters *Editing header data* and *Seismic and header data import* describing new fields in *Header|Profile* and *File|Import Data* dialogues. Updated chapter *Introduction*.
- Oct 5, 2020 : added Fig. 18 to Aaknes-1 tutorial showing prompt to improve your first break picks regarding the traveltime reciprocity principle if RMS error exceeds 5 percent
- Oct 3, 2020 : allow toggling of *File|Import Data|Reverted spread layout* checkbox for import data types SEG-2 and SEGY only. For all other data type selections this checkbox is disabled and reset.

- Oct 2, 2020 : added ***File|Import Data|Reverted spread layout*** checkbox. For previous 4.01 build use *File|More import Settings|Reverted receiver spread layout* option instead. See below in Sep 24 bullet.
- Sep 30, 2020 : use free SeiSee software for viewing of SEGY trace headers
- Sep 29, 2020 : always update shot point coordinates with true coordinates stored in SEG-2 trace header when batch-importing with .HDR batch file. Don't interpolate between receiver coordinates.
- Sep 28, 2020 : don't show irrelevant geometry warning prompts for shot stations outside first/last profile receiver station.
- Sep 27, 2020 : do not check *File|Import data Settings|Extrapolate receiver line coordinates* every time user selects a profile in *File menu*. Uncheck this setting when user creates a new profile and when resetting import settings to defaults.
- Sep 26, 2020 : support import of SEGY .SGY with missing traces for free trial with *File|SEGY import Settings|No receiver coordinates specified in .SGY file* unchecked
- Sep 26, 2020 : ask user to confirm warning prompt when resetting DeltatV & WET parameters to .PAR file belonging to .GRD selected in different profile.
- Sep 25, 2020 : updated our SR6 tutorial. Uncheck *File|Import data Settings|Extrapolate receiver line coordinates* before importing the SEG-2 .DAT files so off-end shotpoints get absolute coordinates specified in the .DAT. Otherwise the following update with SHOTPTS.SHO does not work.
- Sep 24, 2020 : check ***File|More import Settings|Reverted receiver spread layout/towed streamer*** if spread channel no. decreases with inline offset along profile. Check for towed streamer with channel no. 1 closest to towing device and recorder. Also check *File|Import Data|Turn around spread* to unflip reverted spread for display and processing. Use with SEG-2 and SEGY formats.
- Sep 20, 2020 : determine *Layout start* and *Shot pos.* in station numbers for SEGY import as for SEG-2 import with ***Import Data|Turn around spread*** checked. Use for marine refraction with towed spread.
- Sep 20, 2020 : regard *Import Data|Take shot record number from* selection **`DOS file name`** when importing SEGY files with just one shot per .SGY file. Select option **`Record number`** to determine SEGY shot number from SEGY header field **`Field Record No`**. We allow a shot number range 0…999. The imported shot number is set to SEGY shot number modulo 1000.
- Sep 19, 2020 : support importing SEGY .SGY files with missing traces with import option *Allow missing traces* checked and with SEGY option *No receiver coordinates specified in .SGY* unchecked.
- Sep 17, 2020 : added new field ***First receiver [station number]*** to *Header|Profile* dialog. Check box *Force first receiver* to enforce *First receiver [station number]* during import with *File|Import Data…*
- Sep 17, 2020 : *First receiver [station number]* is not forced during import with .HDR batch import enabled or with *File|Import Data Settings|Profile start is default layout start* checked or when importing ASCII.ASC files which specify fixed station numbers already.
- Sep 15, 2020 : ***Copying minimized WET smoothing settings optimized for one profile to another profile is not recommended and not supported***. Default full WET smoothing filter size and default wavepath width are determined automatically based on grid dimensions (grid cell size, number of columns & rows), velocity distribution in the starting model and maximum picked time. Since these parameters are specific to each profile and starting model you need to always start with our Smooth inversion. Next you can optionally try step-wise decreasing of WET smoothing, for consistently picked traveltimes and correctly specified recording geometry.
- Sep 14, 2020 : updated install3.36 tutorial : you need to run your custom rayup336.exe installer (matching your license number programmed into your USB dongle) after running the base installer raywn336.exe. Or run rayup401.exe after raywn401.exe for version 4.01. See our email with detailed installation/update instructions.
- Sep 10, 2020 : updated free trial installer comes with latest help file and works with Surfer 19 Beta
- Sep 9, 2020 : regard ***Grid|GS CENTERED font*** option when plotting source symbols (as red circles instead of red triangles). To install updated **`.BAS`** Surfer scripts download & run Ray336_Scripts.exe on PC where you installed our version 3.36 or 4.01 software.
- Sep 9, 2020 : plot source and receiver symbols at correct horizontal offset when imaging turned-around grid with *Grid|Surfer plot Limits* activated.
- Sep 7, 2020 : version 4.01 completes 10 WET runs for our 1_1D tutorial in about two minutes on 2020 macMini with 3.0 GHz 6-Core Intel Core i5 processor, using 4 cores in Parallels Desktop 16. This takes about 3 minutes on 2017 iMac with 2.3 GHz Intel Core i5 processor using 4 cores, in Windows 7 64-bit Pro virtual machine running under Parallels Desktop 16.
- Sep 4, 2020 : added more links and recommendations to our tutorial AAKNES-1 on last two pages.
- Sep 1, 2020 : added link to Sheehan et al. 2005 in tutorial AAKNES-1. Sheehan et al. objectively compare our fail-safe default Smooth inversion method using 1D-gradient starting model with other commercially available seismic refraction tomography software.

- Aug 30, 2020 : added option *WET Tomo|WET tomography Settings|Cache AWE receiver grids in local memory*. Can be enabled for our Pro version only. This helps to speed up WET inversion when using more than 4 logical CPU cores with option *Enable AWE physical memory page caching* checked. Tested with 6 CPU cores on Apple 2020 macMini. However WET still runs faster when using 4 CPU cores only instead of all 6 cores.
- Aug 23, 2020 : added more figures to new tutorial AAKNES-1
- Aug 18, 2020 : updated figures in new tutorial AAKNES-1 : increase *WET wavepath width* from default 6.5% to 12% for more robust inversion with uncertain recording geometry & first break picks. Show good correlation of *Refractor|Offset breaks* display with WET tomogram. Updated text.
- Aug 13, 2020 : Carollo et al. describe Joint interpretation of seismic refraction tomography and electrical resistivity tomography by cluster analysis to detect buried cavities (JAG July 2020). See also Capizzi et al. (Univ. Palermo 2017).
- Aug 13, 2020 : Colombo et al. nicely explain the 3D CMP refraction recording geometry and apparent velocity processing using CMP bins (SEG Geophysics 2016). This has been described earlier e.g. by Thomas Ruehl 1995 : Determination of shallow refractor properties by 3D-CMP refraction seismic techniques. EAGE First Break 1995, volume 13, pp. 69-77.
- Aug 13, 2020 : our latest tutorial AAKNES-1 shows smooth WET interpretation of dense refraction survey with uncertain picks due to low signal-to-noise ratio. We show WET inversion using both the default 1D-gradient starting model and Plus-Minus method layered refraction starting model.
- Aug 10, 2020 : we don't yet have permission from NGU to publish our new NGU21 tutorial so we had to delete this again from our website.
- Aug 10, 2020 : in our new tutorial NGU21 we now also show *Conjugate-Gradient WET inversion* using Plus-Minus starting model and minimal WET smoothing. This seems to improve the resolution.
- Aug 8, 2020 : our new tutorial NGU21 shows *Smooth inversion using 1D-gradient and Plus-Minus method starting models*. After 100 WET iterations the WET output is almost identical.
- July 31, 2020 : version 3.16 of our software released in 2010 and earlier versions do not work with WibuKey Win32 / Win64 driver 6.00a and later driver versions. The dongle manufacturer changed the encryption method and communication protocol with the dongle for driver 6.00a and later in 2010.
- July 31, 2020 : Ortega Perez et al. use SRT and OSL (Optically Stimulated Luminescense) to determine evolution of water storage capacity for the four Melque reservoirs in central Spain during the period A.D. 600–1900 (Geoarcheology 2017). Refraction profile sediment depths were cross-checked by manual augering.
- July 30, 2020 : Capizzi et al. use ERT & SRT & cluster analysis for imaging of cavities validated with synthetic data (Univ. Palermo 2017)
- July 30, 2020 : Carollo et al. show joint interpretation of seismic refraction tomography and electrical resistivity tomography by cluster analysis to detect buried cavities (JAG July 2020)
- July 29, 2020 : Hutchinson et al. show Stratigraphic Analysis with Refraction Tomography (GSA 2019)
- July 23, 2020 : updated free trial installer comes with latest help file and works with Surfer 19 Beta
- July 22, 2020 : updated `.BAS` Surfer scripts work with latest Surfer 19 Beta. Download & run Ray336_Scripts.exe on PC where you installed our version 3.36 or 4.01 software.
- July 20, 2020 : after updating to Windows 10 May 2020 Update you need to rerun our help installer .
- July 15, 2020 : show fewer status bar messages when back-projecting residuals during WET inversion
- July 13, 2020 : show fewer status bar messages when forward modeling traveltime over velocity grids
- July 13, 2020 : limit size of buffer allocated for reading or writing Surfer format .GRD files to actual size of the data before reading or writing the data section. Earlier builds allocate maximum size allowed in .GRD data section.
- July 11, 2020 : before importing SEG-2/SEGY/GeoTomCG .3DD trace files with irregular receiver spacing check *File|Customize spread types* items *Customize Default spread type&One spread per shot*. This allows more accurate modeling of recording geometry and receiver positions as shown in *Header|Receiver*. Please note that you cannot open such a profile database with older version 3.36 or 3.35 builds of our software, once you import shots with these *Customize spread types* items checked.
- July 7, 2020 : we have ported our Pro version to Intel C++ 19 compiler. Our recompiled version 4.01 Pro software now runs up to 10 percent faster, both in Windows 7 64-bit and Windows 10 64-bit.
- July 1, 2020 : recompiled our app with latest Microsoft Visual Studio 2019 for improved conformance with Windows 10 64-bit. We still fully support Windows 7 64-bit as well.
- June 25, 2020 : don't plot receiver station labels on top axis for Borehole spread/line
- June 25, 2020 : reset receiver station labeling in *Grid|Surfer plot Limits* when user opens profile database with older app version and then reopens with version 4.01.

- June 25, 2020 : automatically update profile database with IMPSHOTS.SHO at end of import into *Line type* Borehole spread/line as for Refraction spread/line. This ensures that shot coordinates are always stored correctly in the database. Use *File|Update header data|Update Shotpoint coordinates* with …\INPUT\IMPSHOTS.SHO for version 3.36 builds after import into Borehole spread/line.
- June 22, 2020 : for *Line type* Borehole spread/line write shot station without inline offset into *Shot station* and *Shot pos.* columns in exported ASCII.ASC & BREAKS.LST files.
- June 22, 2020 : uncheck ***File|Import Data Settings|Assume regular/equidistant receiver spacing*** to better support import of irregularly spaced receivers e.g. with GeoTomCG .3DD import into Borehole spread/line. Uncheck to minimize the offset between receiver coordinates and receiver stations as shown in *Header|Receiver*. Check if all receiver spacings are multiples of *Header|Profile|Station spacing*. This option is unchecked per default. Check to restore import behaviour as with older builds.
- June 22, 2020 : moved some options from *File|Import Data Settings* into new menu *File|More import Settings*.
- June 17, 2020 : improved import of GeoTomCG .3DD. Import shots with just one receiver trace.
- June 16, 2020 : we reprocessed OT0608 profile with *Conjugate-Gradient WET using Cosine-Squared update weighting and optimized WET smoothing* to obtain a sharper tomogram.
- June 15, 2020 : we have redone multiscale WET inversion of SAGEEP 11 blind refraction session synthetic data with version 4.01 of our software. We forced the *grid cell size* to 1.0m in *Header|Profile.* See Fig. 21 on last page of our updated tutorial.
- June 13, 2020 : Geophysical investigations of pyroclastic density current processes and deposit properties at Mount St. Helens, Washington (Cleveland Gase Thesis Boise State Univ. 2016)
- June 13, 2020 : Nielson shows hydrogeophysical imaging of critical zone with ERT and SRT (Master Thesis, Boise State Univ. 2017)
- June 12, 2020 : updated description of import settings and DeltatV settings in help file . Also updated chapter on WET tomography processing, paragraph *Decrease WET velocity smoothing.*
- June 12, 2020 : improve error prompt when not enough RAM available for fast WET inversion. Prompt user to force larger *grid cell size* in *Header|Profile* or to install more RAM. Display how much KB of RAM are needed to cache all shot or receiver traveltime grids. Our Pro license can use up to 1TB of RAM under Windows 10 Pro 64-bit for caching of traveltime grids. Our Standard license can use up to 4GB of RAM.
- June 9, 2020 : check *DeltatV|DeltatV Settings|Write new DeltatV settings to .PAR file* to write new setting *Regard mapping for shot offset correction* to .PAR file. Uncheck so older version 3.36 builds of our software can still read newly generated .PAR files.
- June 7, 2020 : moved some commands from *Processing menu* shown with *Trace menu* gather displays, to new *Display menu*.
- June 7, 2020 : updated paragraph *System Requirements* in help file chapter *Introduction*

Version 3.36 released in June 2020 :

- June 6, 2020 : update *Grid|Surfer plot Limits|First station* & *Station interval* fields when user imports (additional) shots into profile database. Set *Station interval* to (profile length)/10 in station numbers. These parameters are used with option *Grid|Receiver station ticks on top axis* checked.
- June 6, 2020 : Liu et al. show Constraints on the shallow deformation around the Main Frontal Thrust in central Nepal from refraction velocities (Tectonophysics 2020).
- June 4, 2020 : *Processing|Edit trigger jitter removal* lets you edit parameters for removal of trigger jitter with *Processing|Remove gun jitter for shot/for all shots* in *Trace|Shot gather* with our Pro version.
- May 30, 2020 : Rodriguez-Pradilla uses P-wave SRT for rock-mass classification and for structural tunnel-reinforcement design (SEG TLE Feb 2015).
- May 26, 2020 : in *Trace|Shot gather display* we now offer ***Processing|Remove gun jitter for shot*** and ***Remove gun jitter for all shots*** commands with our Annual Pro & Permanent Pro software versions. Use with marine refraction surveys to correct trigger delay of shot(s) based on assumed P-wave velocity of 1,500 m/s in water and known distance between source and closest receiver channel. We tested this with our SR6 tutorial data.
- May 26, 2020 : Mattsson et al. compare WET interpretation with conventional refraction processing for imaging of granitic bedrock in Sweden with thin overburden and mapped deformation zones. Mattsson shows deep weathering and diving waves due to gradual increase of velocity with depth in overburden and below top-of-basement. These results are contrary to unrealistic NGU synthetic model 1_1D which shows no increase of velocity with depth inside basement and abrupt velocity increase to over 4,000 m/s

below thin weathering layer or even directly below topography. These extremely sharp velocity increases at layer boundaries with no layer-internal velocity gradients prevent reliable interpretation with our DeltatV method. DeltatV assumes diving waves due to gradual increase of velocity with depth. This assumption is realistic for most field surveys we have ever seen. See our tutorials in archives TUTORIAL.ZIP and OLDTUTOR.ZIP for interpretation of client's field survey data.

- May 26, 2020 : our Plus-Minus starting model works fine for WET inversion of NGU model 1_1 synthetic traveltime data.
- May 26, 2020 : our default Smooth inversion method is able to determine a good 1D-gradient starting model for WET inversion of NGU P1_6-7D synthetic model data. This NGU model is more realistic than model 1_1D and shows deep weathering with a wide low-velocity fault zone, allowing for diving waves.
- May 22, 2020 : plot overburden refractor over whole profile length for *Wavefront method* depth and velocity sections. Tested with our GEOXMERC tutorial.
- May 21, 2020 : DeltatV apparent velocity pseudo-sections can be compared to ER apparent resistivity pseudo-sections. See e.g. https://pages.mtu.edu/~ctyoung/LOKENOTE.PDF chapter 2.3 on page 8. Quote : "The pseudosection is useful as a means to present the measured apparent resistivity values in a pictorial form, and as an initial guide for further quantitative interpretation. One common mistake made is to try to use the pseudosection as a final picture of the true subsurface resistivity."
- May 21, 2020 : write *DeltatV|DeltatV Settings|Regard mapping for shot offset correction* to .PAR file & restore from .PAR file
- May 21, 2020 : use larger font size for printing of axis legends and labels. Tested with HP OfficeJet Pro 8720 & Adobe PDF & CutePDF Writer printer drivers.
- May 21, 2020 : fixed printing Plus-Minus depth and velocity sections
- May 18, 2020 : new option *Mapping|Smooth CMP curves in Refractor|Midpoint Breaks*. Earlier builds regard *DeltatV|DeltatV Settings|Smooth CMP traveltime curves* for *Refractor|Midpoint breaks*.
- May 18, 2020 : initialize Surfer grid size same way as before Feb 27, 2020. This results in finer grids. You can always force the *grid cell size* in *Header|Profile*.
- May 18, 2020 : update *Grid|Surfer plot Limits|First station* & *Station interval* fields when user opens existing profile database with this latest version.
- May 18, 2020 : update *Grid|Surfer plot Limits|First station* after user imports (additional) shots.
- May 17, 2020 : as shown in our SAGEEP10 short course tutorials and our short manual we always recommend running our Smooth inversion as a first step during interpretation. Next you can try to improve the resolution by increasing the number of WET iterations and decreasing WET smoothing.
- May 17, 2020 : for typical field surveys with traveltime curves showing deep weathering and reciprocal traveltime picking errors and recording geometry errors always first use ***default Full WET smoothing***.
- May 17, 2020 : ***copying minimized WET smoothing settings optimized for one profile to another profile is not recommended and not supported***. Default full WET smoothing is determined automatically based on grid dimensions and velocity distribution in the starting model. Since these parameters are specific to each profile and starting model you need to always start with our Smooth inversion. Then you can try step-wise decreasing of WET smoothing.
- May 17, 2020 : ***if you decrease WET smoothing too much then you effectively prevent WET inversion from improving on the starting model***. This is true for any starting model : Plus-Minus, pseudo-2D DeltatV or 1D-gradient obtained with our *Smooth invert|WET with 1D-gradient initial model*.
- May 17, 2020 : you need to ***interactively adapt WET smoothing to your profile data*** (first breaks and recording geometry). Don't force some arbitrary smoothing copied from another profile and assume that this should just work with your current data. This is not supported.
- May 17, 2020 : for multi-run WET inversion of synthetic data as shown in SAGEEP11_16 tutorial you can decrease ***WET smoothing*** more than for single-run WET inversion of field surveys as shown e.g. in our new P6 tutorial. For P6 we leave WET smoothing at default *Full smoothing* and increase the *WET iteration count* only, from default 20 to 100. But we keep using default *Ricker differentiation -1 [Gaussian]*, default *Steepest Descent search method* and default *Full smoothing*.
- May 8, 2020 : select which CPU cores are used for our application in Windows Task Manager
- May 8, 2020 : or specify CPU affinity with start /AFFINITY command in Windows Command Prompt. Determine the AFFINITY mask value in Windows Calculator in Programmer mode.
- May 8, 2020 : our Standard license can use up to 4 CPU cores for WET inversion. Our Pro license can use up to 16 CPU cores in parallel for faster WET inversion.
- May 8, 2020 : our Standard license can use up to 4 GB RAM under Windows 7/8/10 64-bit. Our Pro license can use up to 1 TB RAM under Windows 10 Pro 64-bit.
- May 6, 2020 : we have updated our brochure with latest specifications.

- May 3, 2020 : Díaz-Curiel et al. use WET inversion and dynamic probing super-heavy tests to determine dynamic moduli, stress–strain moduli relationships and bearing capacity for helipad construction (JAG Apr 2020)
- May 2, 2020 : Macklin et al. show Strain-dependent Stiffness of the Weathered Melbourne Formation (15th Australasian Tunnelling Conference 2014, Sydney) with downhole VSP and pressuremeter tests
- Apr 30, 2020 : updated free trial installer comes with latest help file and works with Surfer 18
- Apr 29, 2020 : updated help file chapter *Introduction*. Add popup help topics for new import options and Grid menu options. Refer to new tutorials.
- Apr 29, 2020 : for inspection of SEGY trace headers use SeiSee software. Also supports bandpass filter and flexible trace display.
- Apr 27, 2020 : our P6 tutorial shows fault zone imaging in Norway. Traveltime curves and results show gradual increase of velocity with depth below topography and deep weathering along fracture zone. This contrasts with the strictly Plus-Minus layered refraction assumption used by NGU for their modeling, with unrealistic abrupt velocity increase to over 4,000 m/s directly below thin weathering layer or topography. We have asked NGU to use more realistic models of weathered subsurface in future, with deep weathering. The modeled velocity should increase gradually with depth both in overburden and in basement. Of course the Plus-Minus method works best for synthetic data obtained by forward modeling over such strongly layered models.
- the SAGEEP 11 blind refraction model uses more realistic velocity gradients and deep weathering including a dipping fault zone, all of which are better modeled with diving waves and seismic refraction tomography than with strictly critically refracted rays used with classical refraction methods.
- (Hagedoorn 1959) already shows Fresnel volumes (seismic transmission volume) and gradual increase of velocity with depth both in basement and in overburden, resulting in curved rays and diving waves in Fig. 1 of his classical Plus-Minus refraction method paper.
- Apr 26, 2020 : describe how to obtain the .BLN file used for water layer blanking in our SR6 tutorial
- Apr 26, 2020 : show in SR6 tutorial how to call SEG2_EDIT utility to add source/receiver geometry to SEG-2 trace headers using supplied .TXT files
- Apr 24, 2020 : new option *File|Import Data Settings|Use bent line inline offset for shot pos. and layout start*. Check to use accumulated inline offset along bent line (regarding receiver x/y/z) to determine *Shot Pos.* & *Layout Start* in station numbers during SEG-2 & SEGY import. Check this option for our SR6 tutorial. This option is unchecked per default.
- Apr 21, 2020 : more accurately determine *shot pos.* and *layout start* in station numbers during SEGY import for slightly crooked lines as for SEG-2 import, with *File|SEGY import Settings|No receiver coordinates specified in .SGY file* unchecked or with *File|SEG-2 import Settings|Receiver Coordinates specified in .DAT or .SG2 file* checked
- Apr 20, 2020 : improved SEGY import now regards options *File|Import data Settings|Flip sign of X coordinate for all sources and receivers* & *Flip sign of Y coordinate for all sources and receivers*
- Apr 15, 2020 : updated `.BAS` Surfer scripts work with latest Surfer 18. Download & run Ray336_Scripts.exe on PC where you installed our version 3.36 software.
- Apr 15, 2020 : updated free trial installer works with Surfer 18
- Apr 15, 2020 : improved ***DeltatV static corrections***. *Surface-consistent corrections* per default instead of *CMP gather datum corrections*. Decreased default width of ***Topography filter*** used for surface-consistent corrections, from previous 100 to new 15 stations. This prevents over-correction of traveltimes in case of strongly undulating topography. Try disabling static corrections completely with option ***No static corrections*** in *DeltatV|Interactive DeltatV|Static Corrections* dialog.
- Apr 11, 2020 : show in SR6 tutorial how to map traces to refractor, determine *Plus-Minus method* layered refraction starting model and run WET inversion using this layered starting model
- Apr 7, 2020 : show in SR6 tutorial how to suppress velocity inversion artefact in WET tomogram by disabling scaling of WET *wavepath width* & *filter height*
- Apr 5, 2020 : our new SR6 tutorial shows WET inversion of shallow marine refraction data using multiple starting models. We show water layer blanking with sources above the refraction spread.
- Apr 5, 2020 : enable *WET Tomo|WET Velocity constraints dialog* even before running any inversion
- Mar 30, 2020 : added field *Use station index or station no. offset* to *Grid|Surfer plot limits* dialog. Check in case of irregular receiver spacing with *Grid|Receiver station ticks on top axis*, see below.
- Mar 28, 2020 : new Grid menu option ***Receiver station ticks on top axis***. Shows station numbers on top axis. Configure as in next bullet. On bottom axis we still always show horizontal inline offset.
- Mar 27, 2020 : added fields *First station* & *Station interval* to ***Grid|Surfer plot Limits*** dialog. Use these to specify first receiver station to be labeled, and the station interval to determine following stations to be labeled with ***Grid|Label receiver stations*** checked.

- Mar 25, 2020 : our Pro version now allows writing & reading Surfer .GRD files with up to 100,000,000 grid cells. Force the grid cell size in *Header|Profile* dialog.
- Mar 23, 2020 : added DeltatV starting model & WET inversion to Mt. Bulga tutorial. Show how to recognize dipping fault zone in common offset sorted raw traveltime plot before any inversion.
- Mar 20, 2020 : updated free trial installer
- Mar 18, 2020 : added DeltatV starting model & WET inversion to SAGEEP11 blind refraction tutorial. Show how WET inversion improves lateral offset errors in DeltatV. Also show how to visualize basement fault zone in CMP sorted raw traveltime data plot before running any inversion.
- Mar 14, 2020 : added DeltatV method interpretation to latest P6 tutorial . DeltatV based WET gives better match to raw traveltime plots than Plus-Minus & 1D-gradient based WET. Improved figure captions.
- Mar 14, 2020 : improve prompt if referenced spread type is missing from reference database. Prompt to import spread types from **`MYSPREAD.SPR`** in your profile directory.
- Mar 14, 2020 : improve prompt during time-to-depth conversion for layered refraction methods if basement refractor coverage is too short
- Mar 10, 2020 : our latest P6 tutorial shows fracture zone detection in bedrock. Also we show **`.HDR`** batch import of **`SEG-2 .SG2`** files with bad recording geometry in **`SOURCE_LOCATION/RECEIVER_LOCATION`** trace header fields. Also we show how to create your **`COORDS.COR`** with elevations.
- Mar 9, 2020 : check ***File|Import data Settings|Database transaction for whole import*** to use one database transaction covering the whole import routine including import of shot traces & updating of trace headers. This option is unchecked per default.
- Feb 29, 2020 : added button ***Reset top elevation*** to *Smooth invert|Custom 1D-gradient velocity profile* dialog. Resets field *Grid top elevation* to highest elevation of any source/receiver along profile.
- Feb 29, 2020 : support blanking of water layer with WET blanking option *Regard negative shot depth* checked and *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* checked.
- Feb 25, 2020 : *Smooth invert* now blanks the initial **`GRADIENT.GRD`** model with **`.BLN`** blanking file selected in *WET Tomo|WET velocity constraints* dialog with option *Blank initial model* checked
- Feb 25, 2020 : added option ***Pad outside border*** in *WET Tomo|WET velocity constraints* dialog. This option is regarded if option *Pad polygon border* is checked only. Tested with `TUNNEL16` tutorial. Uncheck *Pad outside border* to pad inside polygon border with *Pad polygon border* checked.
- Feb 23, 2020 : updated free trial installer
- Feb 23, 2020 : prompt to specify valid *weathering velocity v0* in *Header|Station* when user clicks button ***Correct breaks*** with *DeltatV|DeltatV Settings|Regard mapping for shot offset correction* checked or prompt to uncheck this option. *Refractor|Shot breaks|Mapping menu* shares the same option.
- Feb 19, 2020 : added button ***Redisplay Grid*** to *Grid|Surfer plot Limits* dialog. For older builds use *Grid|Image and contour velocity and coverage grids* instead.
- Feb 19, 2020 : *Grid|Surfer plot Limits* settings are not regarded when displaying the initial 1D-gradient or DeltatV starting model. To redisplay the starting model use above *Redisplay Grid* button and select **`…\GRADTOMO\GRADIENT.GRD`** or **`…\TOMO\DELTATV.GRD`** .
- Feb 19, 2020 : force the grid limits for the starting model using our *Smooth invert|Custom 1D-gradient velocity profile* dialog.
- Feb 18, 2020 : use *Surfer Grid Info* command (in Surfer 11 *Grid menu*) to display the grid cell size for **`…\GRADTOMO\VELOIT20.GRD`** etc. You can force the grid cell size in our *Header|Profile* .
- Feb 16, 2020 : fixed using option ***depth below topo*** in *DeltatV|Interactive DeltatV|Export Options*
- Feb 16, 2020 : alternatively use command ***Grid|Convert elevation to Depth below topography***. Image the converted **`.GRD`** with *File|Image and contour velocity and coverage grids*.
- Feb 10, 2020 : retry deleting flag files used for communication with Golden Software Scripter when plotting starting models & WET tomograms. Theses files may be locked by anti-virus scanner.
- Feb 10, 2020 : don't crash with *Trace gather* window(s) open when user confirms to continue with *WET inversion* using the layered refraction starting model obtained with Plus-Minus method etc.
- Feb 9, 2020 : uncheck ***DeltatV|DeltatV Settings|Weigh picks in CMP curves*** for short or low-coverage lines to avoid over-interpretation and artefacts. This helps for 1_1D DeltatV inversion & CLUD1 Smooth inversion with more realistic 1D-gradient starting model.
- Feb 9, 2020 : for long and high-coverage lines check ***DeltatV|DeltatV Settings|Smooth CMP traveltime curves & Suppress velocity artefacts***. These options are not recommended for short/low-coverage lines.
- Feb 9, 2020 : add exceptions for Windows Defender in Windows 10 Security Center, for root folder **`C:\RAY32`** and file **`C:\RAY32\BIN\RAYFRACT32.EXE`** to improve robustness of our app when plotting models in Surfer and when running WET inversion

- Feb 3, 2020 : updated tutorial NGUP1_1. In *Refractor|Shot breaks* check ***Mapping|Pick branch points between receivers*** & uncheck ***Automated updating of station V0*** before picking the branch points adjacent to shot positions.
- Jan 26, 2020 : *File|Import data Settings|Extrapolate receiver line coordinates* is checked whenever you (re)open a profile database. Uncheck to force *shot station* coordinates for offend shots to *shot point* coordinates listed in **SHOTPTS.SHO** .
- Jan 26, 2020 : restored *DeltatV* resolution when inverting NGU 1_1D synthetic data
- Jan 26, 2020 : show error prompt and exit our app when starting up under Microsoft Windows XP. Prompt to run under Windows 7/8/10 .
- Jan 16, 2020 : redetermine shot dx/dy/dz offset from *shot station* for not reimported shots, at end of import after automatic updating with **IMPSHOTS.SHO** . Next we redetermine *inline* and *lateral offset* from shot station for all shots in profile database.
- Jan 15, 2020 : adapt **.HDR** batch import so works with absolute shot point coordinates in shot records
- Jan 13, 2020 : store absolute shot point coordinates x/y/z in shot record in database. Previously we stored relative dx/dy/dz offset from *shot station* x/y/z in shot record only.
- Jan 7, 2020 : updated SAPRI12 tutorial : check ***Smooth invert|Smooth inversion Settings|No shot position checking*** if shot positions don't exactly match traveltime curve minima in *Refractor|Shot breaks* display to avoid error prompts. Use this option as a last resort only to avoid bad interpretations.
- Jan 7, 2020 : regard lateral offset from extrapolated receiver line for shot points just outside first/last receiver station when determining SEG-2 shot station number
- Jan 2, 2019 : faster trace display in *Trace|Shot gather*
- Jan 2, 2019 : faster mapping of traces to refractors in *Refractor|Midpoint breaks* display
- Jan 2, 2019 : determine SEG-2 *Shot pos. [station no.]* more consistently regarding accumulated inline offset along receiver line
- Jan 2, 2019 : speed up caching of receiver geometry over all shot files contained in input directory selected in *File|Import Data*
- Dec 30, 2019 : updated help file chapter *Introduction*
- Dec 27, 2019 : Gaines et al. detect perched water bodies using surface-seismic time-lapse traveltime tomography (SEG 2010)
- Dec 25, 2019 : write new *WET Tomography Settings|Blank & Write* submenu flags to **.PAR** file
- Dec 24, 2019 : updated help file chapter *Seismic and header data import* : describe ***File|Import Data|Take shot record number from*** choices for *Import data type* SEG-2 .
- Dec 19, 2019 : to import SARA srl SEG-2 shot files which are named by time stamp : ***set File|Import Data|Take shot record number from*** to choice ***File Number***. Our latest 3.36 build will then sequentially number the imported shots, starting at *Shot no.* 1 as shown in *Header|Shot*.
- Dec 19, 2019 : with SEG-2 keyword SHOT_SEQUENCE_NUMBER specified in SEG-2 trace headers our import routine will use these values to number imported shots, with ***File|Import Data|Take shot record number from*** set to choice ***File Number***. Otherwise we number imported shots sequentially.
- Dec 19, 2019 : write a **.HDR** batch file in *File|Import Data* and edit the ***Shot no. in db*** in column 3 as you like. Then select the edited **.HDR** with button *.HDR batch* & click *Batch import* & *Import shots*.
- Dec 18, 2019 : make **.HDR** batch import more robust. Detect too long shot filenames in **.HDR** file when resulting in full file paths (including drive and directory) exceeding Windows limit of 260 characters.
- Dec 16, 2019 : we now quote *shot filenames* in **.HDR** batch files generated in *File|Import Data* with enclosing "". Special filename characters including space chars. and column separators ':,; are preserved when running the **.HDR** batch.
- Dec 16, 2019 : we still support running old **.HDR** batch files with unquoted filenames in *File|Import Data*. But for these unquoted shot filenames we don't allow space chars. and column separators.
- Dec 12, 2019 : more robust determination of *Shot no.* during **SEG-2** import : number shots sequentially if shot no. can't be determined from *DOS file name* or SEG-2 *File number* or *Record number*.
- Dec 10, 2019 : write new *WET smoothing parameters* to **.PAR** file & restore from **.PAR** .
- Dec 9, 2019 : check *WET Tomo|WET velocity constraints|Blank initial model* to blank the starting model **.GRD** with *blanking file* selected in same dialog. Also check *Polygon blanking active*.
- Dec 7, 2019 : limit time zoom with **CTRL+F1** in *Refractor|Midpoint breaks* to 8 levels as previously.
- Dec 2, 2019 : our latest 3.36 build works fine under Windows 10 64-bit Pro, Nov 2019 update.
- Dec 2, 2019 : improved error prompt if bad velocity in grid during WET, with negative shot depth.
- Dec 1, 2019 : Storniolo shows Wetting Front Geometry and Fluid Migration in the Vadose Zone Using Surface Time-Lapse Seismic First-Arrival Tomography (Univ. of Tennessee, Knoxville 2012).
- Dec 1, 2019 : Frydenlund correlates SRT with ERT & borehole data (NTNU Trondheim 2017).

- Nov 27, 2019 : smooth weathering velocity for *Plus-Minus/Wavefront/CMP intercept-time refraction* using smoothing filter width *Overburden filter [station nos.]* specified using **ALT+M** in depth section.
- Nov 27, 2019 : check *Depth|Depth conversion Settings|Don't smooth weathering velocity* to skip smoothing of v0 during layered refraction interpretation with *Plus-Minus/Wavefront/CMP refraction*.
- Nov 23, 2019 : Zhang describes how to determine RQD from visual core inspection and from P-wave velocity measurement on intact core (in laboratory) & in-situ rock mass (in field).
- Nov 22, 2019 : updated free trial installer
- Nov 21, 2019 : *WET Tomo|WET tomography Settings|Force RAM allocation* now runs WET with *traveltime grid caching* enabled for even less available memory than for previous builds.
- Nov 20, 2019 : regard current setting of option *Conjugate Gradient* in main WET dialog when resetting *WET velocity smoothing* via *Reset* button. Set *Damping* to 0.9 and *Maximum velocity update* to 15% for *Conjugate Gradient* method. Set to 0.0 & 25% for *Steepest Descent* method.
- Nov 20, 2019 : don't assert with *WET wavepath scaling* and negative shot depth when re-selecting starting model. For earlier builds uncheck *WET Tomo|WET tomography Settings|Scale wavepath width*.
- Nov 17, 2019 : Toto et al. show fault characterization using ERT & SRT & seismic reflection & impressive geological evidence
- Nov 16, 2019 : if you start data import with *Import Shots* button in *File|Import Data…* but then don't import any shots using *End* or *Skip* buttons, the station coordinates in *Header|Station* will remain empty. See next bullet.
- Nov 16, 2019 : reimport automatically backed up coordinates with *File|Update header data|Update Station Coordinates* & **C:\RAY32\<your profile name>\BACKUP\COORDS.COR**
- Nov 15, 2019 : don't check geometry after generating **.HDR** batch file in *File|Import Data …*
- Nov 15, 2019 : *DeltatV|Interactive DeltatV|Static Corrections|Copy v0 from Station editor* works again, after using button *Correct breaks* in *Header|Station*. This is faster than DeltatV option *Automatically estimate v0* for long & densely recorded profiles. Map traces to refractors in *Refractor|Midpoint breaks*.
- Nov 13, 2019 : after mapping traces to refractors in ***Refractor|Midpoint breaks*** press button ***Correct breaks*** in *Header|Station* to correct picks for shot hole depth and shot point lateral offset. Now reopen *Refractor|Midpoint breaks* and remap traces, based on corrected picks. Now select *Depth|Plus-Minus*.
- Nov 13, 2019 : Terzic et al. show Fault Characterization and Dam Seismic Hazard Assessment (Terzic et al. 2019 GHD). See also their slide show showing combination of SRT with trenching.
- Nov 10, 2019 : *DeltatV|DeltatV Settings|Regard mapping for shot offset correction* with negative or positive *Shot depth* and layered subsurface for improved correction of your first break picks during *DeltatV inversion* and when computing the 1D-gradient starting model with *Smooth invert*.
- Nov 10, 2019 : improved checking of maximum allowed *CMP stack width* for *DeltatV inversion* and *Refractor|Midpoint breaks display*. Regard available RAM/virtual memory.
- Nov 10, 2019 : select *Refractor|Reset Midpoint breaks CMP stack width to default* if you increased the *CMP stack width* too much in **ALT+M** mapping dialog & the display does not open any longer.
- Nov 8, 2019 : we strongly recommend to use our ***1D-gradient starting model*** for WET inversion to avoid artefacts in the *DeltatV starting model*. See Nurul Nida et al. 2019 and Sheehan et al. 2005 and our .pdf reference chapters *DeltatV inversion* & *Smooth inversion* & *WET tomography*
- Nov 8, 2019 : for *DeltatV inversion* theory & usage recommendations see our 2011 paper.
- Nov 8, 2019 : faster validation of *DeltatV CMP stack width*. Automatically decrease stack width if not enough RAM available, for *Automatic DeltatV&WET inversion*.
- Nov 5, 2019 : Mapping sand and clay-filled depressions on a coastal chalk clifftop using gravity, SRT and borehole data for landslide hazard assessment in Normandy, France (Jacob et al. BRGM 2018)
- Nov 5, 2019 : improved contour level setup in **.BAS** Surfer scripts and tested with latest Surfer 17 Beta. Download & run Ray336 Scripts.exe on PC where you installed our version 3.36 software.
- Nov 2, 2019 : in *Refractor|Shot breaks* check ***Mapping|Regard mapping for shot offset correction*** for better correction of first breaks for negative shot depth for marine refraction surveys using our *DeltatV* & *Smooth inversion*.
- Nov 2, 2019 : the CmStick USB dongle driver / ***CodeMeter runtime version 6.90*** is not supported any longer under Microsoft Windows XP. See link for supported Windows versions.
- Nov 2, 2019 : if you need to run our latest software version 3.36 under Windows XP 32-bit we can build a custom version for you using CodeMeter runtime version 6.81.
- Nov 2, 2019 : *Grid|Blank polygon area in grid* works with both **.GRD** and blanking file **.BLN** specified in feet & *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* checked .
- Nov 2, 2019 : increased default ***CMP stack width*** to max. 300 for *DeltatV|Interactive DeltatV* and max. 40 for *Refractor|Midpoint breaks*. Formula : stack width [in CMP's] = (profile length in stations)/5 .

- Nov 2, 2019 : more robust error handling when RAM memory allocation fails. Display prompt with clear message. Then shut down our app once the user clicks OK button.
- Oct 25, 2019 : check ***WET Tomo|WET tomography Settings|Blank|Regard negative shot depth*** for marine refraction surveys with sources above the receiver spread. See bullets dated Sep 22.
- Oct 25, 2019 : for marine refraction survey set *WET Tomo|Interactive WET tomography|Min. velocity* to e.g. 1,300 m/s to force the minimum velocity obtained in WET tomograms.
- Oct 25, 2019 : for marine refraction surveys blank the starting model with *Grid|Blank polygon area in grid* and the blanking file obtained with *Grid|Generate blanking file between sources and receivers*.
- Oct 25, 2019 : *WET Tomo|WET velocity constraints|Pad polygon border* is now unchecked per default.
- Oct 25, 2019 : to zoom traveltime curves in *Refractor|Shot breaks* press ALT+P. Edit *Minimum&Maximum station number* & *Maximum time*. Hit ENTER key to accept changes.
- Oct 19, 2019 : see new help .pdf for screen shots showing installation of Visual C++ 2017 runtime with **`raywn336.exe`** base installer used for installation of latest version 3.36 of our software
- Oct 19, 2019 : Ostrowski & Lasocki show landslide characterization using SRT and ERT (Porto 2018)
- Oct 16, 2019 : improved **`SEG-2`** & Geometrics PlotRefa **`.VS`** import with import options *Allow missing traces* & *Adjust Receiver station coordinates* both checked & when not re-importing all shots.
- Oct 16, 2019 : don't allow toggling import options in *File|Import data Settings* submenu when shots have been imported already. Prompt the user to export and backup header data & select *File|Reinitialize Profile* & reenter *Header|Profile* info & then adjust import options from their defaults. This is required to ***prevent corruption of the profile database & recording geometry***.
- Oct 16, 2019 : more robust *WET inversion* with *Ricker differentiation* set to -2 *[Cosine-Squared]*. Prevent *math exception prompts* with pow function. Dismiss these with *OK button* for older builds.
- Oct 9, 2019 : as a rule of thumb set *DeltatV|Interactive DeltatV|CMP curve stack width [CMPs]* to ***(line length in station numbers)/5***. E.g. with line length of 500m assuming a *Station spacing* of 2m set *CMP curve stack width* to 50. For line length of 2km set to 200. With a station spacing of 4m set to (line length in meters)/20. But set to at least 20, especially for short receiver spreads.
- Oct 7, 2019 : updated topic *Edit velocity smoothing* in help file chapter *WET tomography processing.* Use latest `winhelp.exe` installer. Also updated chapters *Commands* & *Seismic and header data import* & *Pseudo-2D DeltatV inversion* : improved description of interactive DeltatV parameters.
- Oct 7, 2019 : updated SAPRI12 tutorial showing import of **`SeisImager PlotRefa .VS`** . In *Trace|Shot gather* check *Processing|Show dead traces* so you can repick shot no. 8 as described in the tutorial.
- Oct 7, 2019 : our CLUD1 tutorial shows import & Smooth invert of Optim® SeisOpt @2D data files
- Oct 6, 2019 : Zelt et al. 2013 compare refraction tomography software using synthetic data for a known fault model.
- Oct 6, 2019 : Jacob et al. use gravity, SRT and borehole data to map sand and clay-filled depressions on a coastal chalk clifftop for landslide hazard assessment (BRGM 2018)
- Oct 6, 2019 : added check box ***No smoothing*** in *WET Tomo|Interactive WET tomography|Edit velocity smoothing dialog*. Click this button to completely disable *WET smoothing*. See next bullet.
- Oct 6, 2019 : for older 3.36 builds ***completely disable WET smoothing*** as follows : set *Smooth nth iteration : n* = to 100 and uncheck both *Smooth velocity update* & *Smooth last iteration*.
- Oct 6, 2019 : updated **`TUNNEL16_HoleTomo_Mar14.RAR`** archive with latest version 3.36 **`.GRD`** & **`.PAR`** files. This archive is referenced from our updated **`TUNNEL16`** tutorial.
- Oct 5, 2019 : for theory of WET inversion see Schuster 1993 paper .
- Oct 1, 2019 : renamed WET smoothing option *Smooth velocity update* to *Smooth update*. Check to smooth velocity update for every WET iteration. Added option *Smooth nth* to smooth velocity update for each nth iteration only. Renamed option *Smooth last iteration* to *Smooth last*. *Smooth velocity update* is per default enabled & *Smooth nth* per default disabled.
- Sep 29, 2019 : improved robustness of **`SEG-2`** import. Commas "," in number strings read from **`SEG-2`** trace headers are converted to decimal points ".".
- Sep 29, 2019 : *WET velocity update* now is smoothed for each nth iteration only. This can improve the lateral resolution in WET tomograms e.g. for our 1_1D tutorial with *Smooth nth iteration* set to 35.
- Sep 28, 2019 : when toggling *File|Import data Settings|Default Layout start is 1* with *Allow missing traces* checked you need to *File|Reinitialize Profile* before reimporting shots to avoid shot point geometry errors
- Sep 25, 2019 : improved *WET velocity constraints* polygon blanking
- Sep 25, 2019 : improved *WET smoothing* when *WET velocity constraints* polygon blanking is activated
- Sep 25, 2019 : *Grid|Blank polygon area in grid* now regards the blanking flag in 2nd column of **`.BLN`** header line. Set to 1 to blank inside & 0 to blank outside. Edit blanking velocity in 3rd column. Our earlier software builds regards *WET Tomo|WET velocity constraints|Blank outside polygon* instead.

- Sep 22, 2019 : ***Grid|Generate blanking file between sources and receivers*** writes Surfer format **.BLN** blanking file to disk with polygon of area between sources and receivers. The ***blanking velocity*** in header column no. 3 is set to 1,500 m/s. Use for water layer blanking for marine surveys with sources positioned above the receiver spread. Specify negative shot hole depths in *Header|Shot* or in **SHOTPTS.SHO** to move sources above receiver spread.
- Sep 22, 2019 : in *WET Tomo|WET velocity constraints* dialog click button *Select blanking file* & select above **.BLN** and check box *Polygon blanking active*. Click button OK to confirm.
- Sep 22, 2019 : *Grid|Generate blanking file between sources and receivers* writes coordinates to the **.BLN** blanking file in feet with *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* checked
- Sep 22, 2019 : when writing **GRADIENT.GRD** and **DELTATV.GRD** starting model grids we automatically extend these grids upwards to include all sources with negative shot hole depths
- Sep 14, 2019 : Himi et al. image landslides with ERT and SRT to determine sliding surfaces and internal landslide structure (EAGE NSG Porto 2018)
- Sep 14, 2019 : *File|Update header data|Delete all first breaks for all shots* deletes all first break picks from your profile database
- Sep 14, 2019 : *File|Update header data|Update First Breaks* deletes shot picks for all shots listed in your selected **BREAKS.LST** before updating shot traces with picks as listed in your **BREAK.LST**
- Sep 14, 2019 : our **SEG-2** import now determines *Layout start* and *Shot pos.* in station numbers based on 3D inline offsets instead of offset along major coordinate. This helps with curved lines.
- Sep 14, 2019 : more robust **SEG-2** import truncates field **ACQUISITION_TIME** to 15 characters before writing to profile database. All other string type **SEG-2** header values are also truncated if too long.
- Sep 9, 2019 : in *Trace|Shot gather* display check *Processing|Show dead traces* to display dead/missing traces. These are always shown with earlier builds of our software. Reimport your **SEG-2** shots with *File|Import data Settings|Allow missing traces* & *File|SEG-2 import settings|Receiver Coordinates specified in .DAT or .SG2 file* checked to suppress display of dead traces.
- Sep 9, 2019 : if *Processing|Show dead traces* is unchecked in *Trace|Shot gather* etc. then we do not allow picking of dead traces, neither with left mouse button click nor with polyline picking
- Sep 3, 2019 : we now support import of x/y/z coordinates specified in SEG-2 trace headers for **SOURCE_LOCATION** and **RECEIVER_LOCATION** keywords. Separate x, y and z coordinates by one or more space characters. Check *File|SEG-2 import settings|Receiver Coordinates specified in .DAT or .SG2 file* and *File|Import data Settings|Allow missing traces* to enable this x/y/z coordinate import.
- Sep 3, 2019 : use SEG2_EDIT http://pubs.usgs.gov/of/2003/ofr-03-141/ to add **SOURCE_LOCATION** and **RECEIVER_LOCATION** fields to SEG-2 trace headers.
- Sep 3, 2019 : ***File|Update header data|Update Receiver Coordinates*** lets you update profile database trace headers with receiver x/y/z specified in columns 6/7/8 of **BREAKS.LST** file. Also we will re-determine receiver station x/y/z coordinates by averaging receiver coordinates linked to that station by common *station number*.
- Sep 3, 2019 : export *receiver x/y/z* coordinates into columns 6/7/8 of **BREAKS.LST** with *File|Export header data|Export First Breaks* with option *File|Export data Settings|Export receiver coordinates to .3DD and .LST* checked
- Aug 19, 2019 : use SEG2_EDIT http://pubs.usgs.gov/of/2003/ofr-03-141/ to stack traces in **SEG-2** formatted shot files
- Aug 16, 2019 : better diagnose ***too short basement refractor coverage*** with *Plus-Minus* method
- Aug 16, 2019 : don't allow *WET Tomo|Interactive WET Tomo|Ricker differentiation* of 1 *[once differentiated Ricker wavelet]* if user actives multirun WET with *Iterate button*
- Aug 15, 2019 : *Header|Receiver* dialog now shows both *Station coordinates* x/y/z and *Receiver coordinates* x/y/z. Station coordinates are copied from *Header|Station* for same *Station number* while Receiver coordinates are the x/y/z imported from *shot file*.
- Aug 12, 2019 : we have uploaded input files for our sinkhole tutorial Tyler Line1 . Also we have reprocessed this data with our latest 3.36 Standard software.
- Aug 12, 2019 : our Rayfract® software offers multiple interpretation methods and parameters to explore the non-uniqueness of the solution space. It is the user's job to sufficiently explore the solution space with our methods and varying parameters, and to find an appropriate combination of methods and parameters for each individual data set. This choice may be guided by a-priori information e.g. from boreholes or other geophysical methods. For good parameter combinations see our tutorials, our short manual and our SAGEEP 2010 short course. We recommend to always first run our *Smooth inversion* method with *1D-gradient starting model*. Next you can increase the *WET iteration count* to 100 in *WET Tomo|Interactive WET*.

- Aug 10, 2019 : Grelle and Guadagno determine WSI Water Seismic Index from P-wave and S-wave surveys along the same line to better map the groundwater table (Journal of Applied Geophysics 2009)
- Aug 5, 2019 : better regard *forced grid cell size* specified in *Header|Profile* for initial model
- Aug 2, 2019 : Manning shows karst imaging over igneous basement correlated with GPR interpretation in his AGU 2019 poster & Youtube video (Texas A&M University 2019)
- Aug 1, 2019 : we per default check again option ***Blank below envelope after last iteration*** in menu *WET Tomo|WET tomography Settings|Blank* for more reliable imaging at bottom of tomogram
- July 28, 2019 : Mendieta shows Seismic Refraction and Electrical Resistivity Tests for Fracture Induced Anisotropy in a Mountain Watershed (Mendieta Master Thesis 2017 Boise State Univ.)
- July 28, 2019 : Benjumea et al. use our *WET inversion* to reconstruct 3D image of the Emporda Basin (Benjumea et al. EUREGEO 2015 Proceedings pp. 29-31)
- July 26, 2019 : updated tutorial CFE15.pdf : check *WET Tomo|WET tomography Settings|Blank|**Blank outside borehole tomogram*** before running *Smooth invert* and *WET Tomo|Interactive WET*
- July 26, 2019 : updated our latest Walkaway19 tutorial : show forcing of *grid cell size* to 0.2m and describe how to pick the topography *blanking file* in Surfer
- July 25, 2019 : as shown by (Watanabe 1999, Fig. 4) for crosshole surveys, it is not possible to reliably image seismic subsurface velocity at a resolution much smaller than one wavelength of dominant frequency of the first break pulse. E.g. with 100 Hz and basement velocity of 4,000 m/s, one wavelength is 4000/100 = 40m. In case of bad or noisy picks and recording geometry errors, resolution may not be better than two wavelengths. For refraction surveys, resolution at bottom and edges of tomogram is further reduced, because here rays and wavepaths are aligned predominantly parallel to each other (White 1989). In our 1_1D tutorial we are imaging fault zones not wider than 10m @ 4,000 m/s. This is far below one wavelength of 40m, see above.
- July 25, 2019 : the minimum-structure **smooth 1D starting model is recommended for robust WET inversion of lines shorter than 0.5 km**, to prevent artefacts caused by the starting model (Sheehan et al. 2005, Fig. 1) and to prevent our WET inversion getting stuck in a local minimum of the traveltime misfit function (Schuster 1993, Equation 1). See our SAGEEP11 presentation, thrust12, epikinv, mtbulga tutorials etc.
- July 25, 2019 : disable *DeltatV|DeltatV Settings|Suppress velocity artefacts* per default. This gives better vertically resolved 1D-gradient starting model when trying to image LVL Low-Velocity-Layers e.g. for our GS0801 and COFFEY04 tutorials. See bullets dated July 1 & July 6th, 2019.
- July 24, 2019 : our latest 3.36 software works fine under Windows 10 64-bit Pro May 2019 update
- July 18, 2019 : don't cache *initial model* `.GRD` any longer & always re-read initial model `.GRD` from disk to (re)determine the width and height of *WET smoothing filter* for *full/minimal smoothing*
- July 15, 2019 : check *WET Tomo|WET tomography Settings|Write|Keep WET smoothing record in database* to keep WET smoothing settings when user changes *grid cell size*. The WET smoothing *filter size* is updated based on the initial model's cell size during next WET inversion except if the user selected *Edit velocity smoothing|Manual smoothing* earlier.
- July 14, 2019 : update *WET velocity smoothing filter size* in database when user (re)selects initial model grid in *WET Tomo|Interactive WET tomography* except if she selected *Edit velocity smoothing|Manual smoothing* earlier
- July 14, 2019 : compare stored *weathering velocity v0* with edited v0 in *Header|Station* with two decimal digits precision to prevent spurious prompts about 'Changed station coordinates'
- July 9, 2019 : reset *WET velocity smoothing* and delete starting model grids when user imports shots or updates header data with station coordinates or shot point coordinates.
- July 8, 2019 : delete …`\HOLETOMO\CONSTVEL.GRD` starting model when user changes/forces *grid cell size* in *Header|Profile*.
- July 8, 2019 : reset *WET smoothing* to defaults and force re-determination of *WET smoothing* when user changes/forces *grid cell size* in *Header|Profile*.
- July 8, 2019 : for earlier builds of our software : after you change/force the *grid cell size* in *Header|Profile* determine a new starting model with *Smooth invert*. Now review and accept WET smoothing in *WET Tomo|Interactive WET tomography|Edit velocity smoothing*. Edit the smoothing as required and click *Accept parameters button*.
- July 6, 2019 : for our COFFEY04 tutorial decrease *WET wavepath width* to 2% or 2.5% from default 3.5%. Uncheck *Disable wavepath scaling for short profile*. Don't *suppress DeltatV velocity artefacts* for 1D-gradient starting model obtained with *Smooth inversion*. These settings give better vertical resolution and show low-velocity layers LVL as in above tutorial in Fig. 1.
- July 5, 2019 : our latest tutorial shows reprocessing of Walkaway VSP data with version 3.36
- July 2, 2019 : *File|Import data Settings|Reset all Import Data settings to default value* resets new import options and *File|Import Data* dialog controls

- July 1, 2019 : we tested our new **GeoTomCG .3DD** import into *Line type* **Refraction spread/line** with our tutorial data OT0608, GEOXMERC and GS0801 after export to **.3DD**. Set *Ricker differentiation* to 1, decrease *WET wavepath width* to 2% from default 4% and uncheck *Adapt filter shape* in *Edit velocity smoothing* for GS0801 to better image the low-velocity layer LVL in the landslide.
- July 1, 2019 : check new options *File|Customize spread types|Customize Default spread type* and ***One spread per shot*** when receiver coordinates vary over time in the same spread layout between shots such as in marine streamer surveys
- July 1, 2019 : use new options *File|Import data Settings|Flip sign of X coordinate for all sources and receivers* and *Flip sign of Y coordinate for all sources and receivers* with import of **GeoTomCG .3DD** if you want to turn around the line during import. We automatically determine the major coordinate as X or Y coordinate depending on which increases faster along the line.
- June 28, 2019 : we increased the default value for parameter ***Maximum tolerance*** to 70 percent in *File|Update header data|Update Station coordinates* dialog. This helps with import of **GeoTomCG .3DD** files into profiles with *Header|Profile|Line type* **Refraction spread/line** profiles.
- June 27, 2019 : we now allow **GeoTomCG .3DD** import into profile with *Line type* **Refraction spread/line** and regard y coordinates for refraction lines
- June 27, 2019 : check *File|Import data Settings|Y coordinate is zero 0.0* to reset y coordinates to zero when importing **GeoTomCG .3DD** files
- June 27, 2019 : check ***File|Import data Settings|Customize Default spread type*** to automatically customize selected *Default spread type* to match irregular receiver layout with missing traces. Enabling this option will cause database revision to fail when opening this profile with earlier 3.36 or earlier version of our software. Enabling this allows more accurate modeling of recording geometry and receiver positions.
- June 19, 2019 : updated Walkaway tutorial with download link for input data
- June 18, 2019 : fixed assertion failure when importing SEG-2 shots into *Line type* **Borehole spread/line** without coordinates specified in SEG-2 files. Click *Ignore button* to skip these prompts.
- June 16, 2019 : we now show the ***Ray Id*** in *Header|Receiver* after import of GeoTomCG .3DD shots
- June 16, 2019 : Petronis et al. image a volcanic cone with SRT and ERT
- June 14, 2019 : enable *DeltatV|DeltatV Settings|Suppress velocity artefacts* per default
- June 14, 2019 : disable *WET Tomo|WET tomography Settings|Blank|Blank below envelope after last iteration* per default when creating a new profile or when resetting WET tomography settings
- June 13, 2019 : updated recommendations on last page of P1_6-7DGrad tutorial. We recommend to always first run our *Smooth invert|WET with 1D-gradient initial model* method. Next you can increase the ***WET iteration count*** and decrease ***WET smoothing*** in *WET Tomo|Interactive WET tomography*. Try both ***Steepest Descent*** and ***Conjugate-Gradient*** methods.
- June 13, 2019 : we now correctly re-determine the *Shot station no.* with ***File|Import Data|Turn around spread*** checked. This helps with import of SEG-2 streamer data.
- June 10, 2019 : Advisian et al. show groundwater exploration with ERT and SRT (Advisian 2016)
- June 7, 2019 : delete **…\GRADTOMO\GRADIENT.GRD & DLTAGRAD.GRD** starting models when importing shots, except when importing synthesized/extrapolated far-offset shots during layered refraction interpretation with Plus-Minus and Wavefront methods
- June 5, 2019 : added Fig. 16 to our 1_1D tutorial showing our new option ***No smoothing***. This option makes it easier to completely disable WET smoothing. Enabled *No smoothing* option overrides all other parameters in *Edit velocity smoothing* dialog except *Maximum velocity update* and *Damping*.
- June 3, 2019 : if *File|Import data Settings|Adjust Receiver station coordinates* is not checked we prompt the user to confirm re-centering receiver stations if one or more receivers are offset from their receiver station, at end of import
- May 30, 2019 : check *File|Import data Settings|Adjust Receiver station coordinates* to ***re-center all receiver stations at average of coordinates for all receivers linked to each station*** at end of import. This helps with importing irregularly spaced streamer data. Tested with SEG-2 streamer shots.
- May 30, 2019 : *File|Reinitialize profile* resets profile to initial state. All imported data, first break picks, recording geometry and results are permanently deleted from the profile.
- May 29, 2019 : check *File|Import data Settings|Check all shots for station spacing* to check all shot files in input directory if they suggest adjustment of the profile's *Station spacing*. Uncheck to check first shot file only.
- May 27, 2019 : support again importing multiple **PlotRefa .VS** and **GeoTomCG .3DD** files into same profile and in same *File|Import Data* session

- May 26, 2019 : check *File|Export data Settings|Export receiver coordinates to .3DD and .LST* to export receiver coordinates specific to each trace. Uncheck to export *receiver station coordinates* which are averaged over all receivers linked to this station.
- May 26, 2019 : our *File|Import Data* now scans all shot files with same *file format* as the selected file in input directory and caches the receiver geometry for all shots. We then map receiver coordinates to station numbers. In a 2nd pass these shots are actually imported into the profile using these station numbers. Tested for **SEG-2** & **GeoTomCG .3DD** & **PlotRefa .VS** file formats.
- May 23, 2019 : we now display *weathering velocity v0* with 4 decimal digits in *Header|Station*
- May 20, 2019 : for detailed help with Golden Software Surfer Automation error messages see https://support.goldensoftware.com/hc/en-us/articles/360006089653-Surfer-Automation-Errors
- May 20, 2019 : also see our .pdf reference on page 208 and our *Help|Contents|Calling Surfer*
- May 20, 2019 : prompt once only during import/for first input file to adjust profile's *Station spacing*
- May 20, 2019 : to not prompt at all to adjust the *station spacing* : uncheck *File|Import data Settings|Adjust profile station spacing* before selecting *File|Import Data*
- May 19, 2019 : we now show imported receiver x/y/z coordinates and receiver offset from receiver station dx/dy/dz in ***Header|Receiver*** dialog
- May 19, 2019 : at end of our import routine we now ***re-center receiver stations*** at average of all actual *receivers* linked to that station. We update receiver dx/dy/dz to offset from repositioned station.
- May 19, 2019 : use *File|SEG-2 import settings|Flip sign of x coordinate for all sources and receivers* if **SOURCE_LOCATION** and **RECEIVER_LOCATION** SEG-2 trace header fields don't increase with increasing **CHANNEL_NUMBER** field
- May 19, 2019 : use *Grid|Turn around grid file by 180 degrees* to flip back resulting tomograms
- May 19, 2019 : updated free trial installer
- May 19, 2019 : fixed **Interpex Gremix .GRM** import for free trial with *Allow missing traces* checked
- May 16, 2019 : we have improved our SEG-2 and GeoTomCG **.3DD** import routines and now better support import of irregular receiver spreads with import option ***Allow missing traces*** and SEG-2 option ***Receiver geometry specified*** checked
- May 16, 2019 : we tested our improved SEG-2 import with a marine hydrophone streamer survey recorded using ***Geometrics GeoEel*** streamer
- May 3, 2019 : we support import of GeoTomCG **.3DD** files picked & exported from REFLEXW
- May 3, 2019 : to import GeoTomCG **.3DD** into *Line type* **Refraction spread/line** first check *File|Import data Settings|Import horizontal borehole survey or .3DD refraction survey*. We assume that all y coords. in **.3DD** files are 0.0 .
- Apr 28, 2019 : when you change the *Shot pos. [station no.]* interactively or via **.HDR** batch file during import with *File|Import Data…* we now automatically update the shot x/y/z coordinates in the **IMPSHOTS.SHO** file after interpolating coordinates for all profile stations at end of import
- Apr 28, 2019 : if you want to edit **IMPSHOT.SHO** first copy it to e.g. **MYSHOTS.SHO** and then edit **MYSHOTS.SHO** and apply with *File|Update header data|Update Shotpoint coordinates*. Our import routine called via *File|Import Data…* overwrites **IMPSHOTS.SHO** each time again.
- Apr 21, 2019 : Savelli et al. investigate landslide with SRT and sediment core
- Apr 21, 2019 : try running our software under Windows 7 64-bit. While our software also works fine under Windows 10 64-bit our *WET inversion* runs about 20% faster under Windows 7 64-bit.
- Apr 21, 2019 : fixed **RECEIVER_LOCATION** values in jenny13.zip SEG-2 **.DAT** files. Deleted extra channels 25 to 48. The fixed **.DAT** files can be imported without issues with our version 3.35 and 3.36.
- Apr 18, 2019 : *File|Import data Settings|Allow missing traces* now is regarded for SEG-2 import if *File|SEG-2 import settings|Receiver Coordinates specified in .DAT or .SG2 file* is checked only
- Apr 18, 2019 : updated free trial installer
- Apr 17, 2019 : *File|Update header data|Update Shotpoint coordinates* accepts again abbreviated **SHOTPTS.SHO** files with last column **upholeTime** as with version 3.35. See **\RAY32\DOC\SHORTPTS.SHO.**
- Apr 16, 2019 : before SEG-2 import into profile jenny13 uncheck *File|Import data Settings|Allow missing traces*. Set *Default spread type* to **01: 24 channels**. Otherwise *Smooth inversion* etc. will not work for this profile due to invalid/extra receiver positions and channels in the **.SG2** trace files.
- Apr 10, 2019 : Bottari et al. map fault zone with ERT, SRT, GPR, magnetic data and cluster analysis
- Apr 10, 2019 : Bottari et al. investigate landslides with ERT and SRT
- Apr 10, 2019 : updated P1_6-7DGrad tutorial. Fig. 15 shows *Smooth inversion Settings*.
- Mar 27, 2019 : write *Conjugate Gradient* iteration no. & *Line Search* iteration no. to **.STX** file
- Mar 26, 2019 : updated 1_1D tutorial; added Fig. 9 showing true model as built by NGU in Fig. 3.1.1
- Mar 26, 2019 : updated P1_6-7DGrad tutorial. Fig. 9 shows true model used by NGU in Fig. 3.1.1 .

- Mar 22, 2019 : our latest tutorial shows ***Conjugate-Gradient WET inversion using 1D-gradient starting model*** for NGU 2018 P1_6-7D synthetic fault zone model.
- Mar 12, 2019 : we now normalize the absolute RMS error with average picked time instead of maximum picked time, over all traces modeled. This results in larger normalized RMS errors.
- Mar 12, 2019 : check *Model|Forward modeling Settings|Normalize RMS error with maximum picked time* to normalize RMS error with maximum picked time
- Mar 12, 2019 : *File|Update header data|Update Geometry* supports again **`.PRN`** files with 3 columns : station no, z coordinate, x coordinate. See your **`\RAY32\DOC\5.PRN`** sample survey geometry file.
- Mar 12, 2019 : allow for missing shot depth in Interpex Gremix **`.GRM`** file
- Mar 11, 2019 : Skenderija investigates mass movement in quarry using ERT and SRT (Zagreb 2018)
- Mar 11, 2019 : Hauck & Hilbich estimate ice content in rock slide using ERT and SRT (Fribourg 2018)
- Mar 6, 2019 : latest CodeMeter & WibuKey drivers are available at this updated URL
- Mar 4, 2019 : changed *Midpoint breaks mapping* parameters *Regression Receiver Count*, *Direct Wave Delta*, *Refracted Wave Offset Delta* from defaults 2/2/3 back to 3.35 defaults 3/3/5. This makes estimation of weathering velocity less susceptible to bad picks or geometry errors at source.
- Mar 4, 2019 : above parameter *Regression Receiver Count* is regarded to determine the weathering velocity used during *DeltatV+XTV* inversion for static correction of first breaks
- Mar 4, 2019 : deleted an unnecessary reference to Visual C++ 2005 runtime from our app rebuilt in Visual Studio 2017. Now our updated app can run without Visual C++ 2005 redistributable installed.
- Mar 3, 2019 : our latest tutorial shows ***Conjugate-Gradient WET inversion using DeltatV+XTV starting model*** for NGU 2018 P1_6-7D synthetic fault zone model. We optimized DeltatV+XTV and WET inversion settings to more clearly image overburden and double fault zone and minimize artefacts.
- Feb 20, 2019 : Valois et al. assess sinkhole geometry using ERT and SRT
- Feb 20, 2019 : Avalos et al. image a buried bedrock valley with SRT using cores and wells
- Feb 18, 2019 : Tomás et al. investigate a landslide with LiDAR, boreholes, GPR and SRT (2018)
- Feb 18, 2019 : Ostrowski & Lasocki show landslide characterization using SRT and ERT (Porto 2018)
- Feb 18, 2019 : Ostrowski et al. show fault zone imaging using SRT (EAGE NSG Barcelona 2016)
- Feb 14, 2019 : fixed extrapolation of basement refractor elevation below first profile receiver with our ***CMP Intercept-time*** layered refraction method. First map traces to refractors in *Refractor|Midpoint breaks* display to enable this *Depth menu* item. See our help chapter *Mapping traces to refractors*.
- Feb 9, 2019 : clear error message if ***Trace|Shot gather*** fails to load traces from a corrupt database. Ask user to reimport shots into a new profile database. This will happen if you open a profile database with version 3.26 or later of our software and next open the database with version 3.25 or earlier. We changed the sample format from 16-bit integer to 32-bit floating point for version 3.26.
- Feb 6, 2019 : ported our Standard and Pro software to ***Visual Studio 2017 & Visual C++ 14***. WET inversion now runs up to 25% faster than in version 3.35 also thanks to Profile-Guided Optimization.
- Feb 6, 2019 : to run our latest version 3.36 under Windows 7 64-bit Pro & Windows XP SP3 download & install Visual C++ 2017 redistributable. This is not needed for Windows 10.
- Feb 6, 2019 : fixed a bug which caused our *Refractor|Shot breaks* display to crash occasionally. For earlier builds of our software press **`ALT+Y`** to refresh this display.
- Jan 28, 2019 : access our extensively hyper-linked help file via our Help menu. Use ***Help menu Contents item*** to browse our help file chapters with embedded links to *DeltatV* and *WET parameters*. Or use ***Help menu item Search for Help On*** to search our help file for a parameter name and description.
- Jan 28, 2019 : for popup help describing interactive *DeltatV/XTV/WET parameters* use TAB key to navigate to interesting parameter field e.g. in *WET main dialog* & in *WET smoothing dialog*. Next press **`F1 key`** to obtain ***popup help window*** describing this parameter
- Jan 25, 2019 : see our new documentation ConfigureAWEforPro.pdf for how to enable use of memory above 4 GB limit for our Annual or Permanent Pro license
- Jan 23, 2019 : when working through our latest tutorials in **`TUTORIAL.ZIP`** be sure to force the ***grid cell size*** in *Header|Profile* e.g. to 0.4m as in 1_1D tutorial. ***WET smoothing filter dimensions half-width and half-height*** are specified in grid columns&rows having the extent of one grid cell.
- Jan 23, 2019 : when you activate ***Conjugate Gradient*** method in *WET Tomo|Interactive WET tomography* the total number of *WET iterations* is determined with the two Conjugate-Gradient specific controls ***CG Iterations*** (outer loop) : 10 per default and ***Line Search iters.*** (inner loop) : 2 per default. This results in 32 *WET iterations* total per default. Field *Number of WET iterations* is ignored for Conjugate Gradient. See also http://www.cs.cmu.edu/~quake-papers/painless-conjugate-gradient.pdf on page 53 : algorithm B5 (Shewchuk 1994). One f'(x) evaluation is done with one WET iteration.

- Jan 9, 2019 : run our BasConvrt.exe installer to update your old Surfer script versions of **AUTOTOMO.BAS** & **DELTATV.BAS** e.g. coming with our version 3.21 so these can work with Golden Software Surfer 11
- Jan 3, 2019 : prompt if **SEGY .SGY** file has bad fields **NS** (number of samples) or **DT** (sample interval) in binary file header. Use **DT** value specified in first trace header if bad **DT** value in file header.
- Dec 31, 2018 : speed up resetting temporary grids to zero or blank value during *WET inversion*
- Dec 30, 2018 : speed up *WET inversion* during iterations with no smoothing
- Dec 28, 2018 : for help on calling Surfer via Scripter see goldensoftware.com tips
- Dec 27, 2018 : added radio button ***No smoothing*** in *WET Tomo|Interactive WET tomography|Edit velocity smoothing dialog*. Click this button to completely disable *WET smoothing*. See next bullet.
- Dec 23, 2018 : to ***completely disable WET smoothing*** set *Smooth nth iteration : n* = to 100 and uncheck *Smooth last iteration* in *WET Tomo|Interactive WET tomography|Edit velocity smoothing*. We showed this in our tutorial sageep11_16.pdf in Fig. 14 in 2016 already for *Conjugate-Gradient multiscale WET inversion*. This also works for our tutorial 1_1D .
- Dec 19, 2018 : updated instructions on how to uninstall and reinstall green WibuKey driver
- Dec 18, 2018 : review install3.36.pdf showing installation of our version 3.36 software under Windows 10 64-bit. Be sure to first disable all of your antivirus software including Windows Defender.
- Dec 16, 2018 : Himi et al. use ERT, SRT and EMT to image seepage and mortar injection zones in an earthen dam (Univ. Barcelona 2018)
- Dec 14, 2018 : limit *WET envelope width* to *WET wavepath width* during ***multirun WET***
- Dec 8, 2018 : Jacob et al. use gravity, SRT and borehole data to map sand and clay-filled depressions on a coastal chalk clifftop for landslide hazard assessment (BRGM 2018)
- Dec 8, 2018 : prompt user if **SEG-2 UNIT** field specifies **FEET** and *Header|Profile|Units* says meter. Ask user to check *File|SEG-2 import settings|Get distance unit from user* and to check *File|Import Data Settings|Default distance unit is meter*.
- Dec 7, 2018 : fixed forcing of *Grid cell size* in *Units* **feet** in *Header|Profile*
- Dec 7, 2018 : added buttons *OK/Cancel/Reset* to *WET Tomo|Coverage plot setup dialog*
- Dec 3, 2018 : added two controls to *WET Tomo|Coverage plot setup dialog* to ***sharpen wavepaths in coverage plot*** : edit *Raise wavepath weight to power* to any value between 0.0 and 100.0. Check box *Sharpen wavepaths active* to enable sharpening of wavepaths. With *Sharpen wavepaths active* unchecked we plot wavepaths as in previous versions of our software.
- Dec 3, 2018 : added two controls to *WET Tomo|WET Update weighting* to ***decrease WET velocity update in high-coverage areas*** of tomogram to ***reduce horizontal smearing artefacts*** : edit ***Velocity update power*** to any value between 0.0..1.0 with default 0.5. With box *Decrease update active* checked we determine the average hit count (wavepaths per pixel) over all tomogram pixels. Next we determine the difference between actual hit count and average hit count for each tomogram pixel. If the actual hit count exceeds the average hit count we then update the pixel's hit count to average hit count plus this difference raised to ***Velocity update power***. We then determine the ratio between updated hit count and original hit count. Finally the velocity update is multiplied by this ratio for each tomogram pixel.
- Nov 30, 2018 : updated 1_1D tutorial and added Fig. 14 showing ***WET Tomo|WET tomography Settings*** *menu*. Uncheck option ***Scale wavepath width*** to prevent velocity artefacts just below topography (at strong topography curvature) and for less horizontal smearing at bottom of tomogram.
- Nov 28, 2018 : **SHIFT+Z** now deletes first break picks in all *Trace menu* gather types. Use e.g. to model gap in profile coverage when forward modeling shots. Delete picks for all traces recorded at receiver station number in gap, with **SHIFT+Z** in *Trace|Receiver station gather*.
- Nov 22, 2018 : tested our latest Standard version 3.36 with Golden Software Surfer version 16.0.330 released on Nov 7, 2018.
- Nov 21, 2018 : show Rayfract® version as v. 3.36 instead of Vers. 3.36 in Surfer plot title
- Nov 21, 2018 : our latest tutorial shows ***multiscale Conjugate-Gradient WET inversion using DeltatV+XTV starting model*** for NGU 2018 P1-1D synthetic fault zone model. We optimized WET inversion settings to more clearly image the 3 vertical fault zones.
- Nov 15, 2018 : check *WET Tomo|WET tomography Settings|Weight velocity update* to decrease velocity update in high-coverage areas of WET tomogram. Can help to avoid lateral smearing artefacts at bottom of tomogram.
- Nov 12, 2018 : Tassis et al. use *DeltatV+layered XTV* & *Plus-Minus* & *Wavefront* refraction methods to obtain an initial model for *WET inversion* of synthetic data modeled for layered subsurface with vertical fault zones (NGU Trondheim, 2018)
- Nov 12, 2018 : don't convert user-selected filenames to all-uppercase
- Nov 9, 2018 : completely read from **.PAR** file filenames with spaces
- Nov 9, 2018 : correctly display initial model filename in Surfer plot for filenames with spaces

- Nov 8, 2018 : to reduce Surfer Kriging artefacts try increasing the grid cell size in *Header|Profile*
- Nov 8, 2018 : we now allow creating and opening profiles using filenames up to 130 characters long, including drive character and directory plus **SEIS32.DBD** database filename
- Nov 8, 2018 : in *File|New Profile…* optionally click on the yellow folder icon at right-top to create a subdirectory. Hit **ENTER** key to enter this subdirectory. Set *File name* to your profile's name.
- Nov 8, 2018 : in *File|New Profile…* we now allow using spaces in *File name* & subdirectory names. Also *File name* can now be longer than 8 characters.
- Nov 6, 2018 : regard *File|Import data Settings|Select file in Profile directory* & *Keep current directory when selecting files* when selecting files in *Grid menu*, *WET Tomo|Interactive WET tomography* etc.
- Nov 6, 2018 : moved directory selection options *Select file in Profile directory* & *Keep current directory when selecting files* into *File|Import data Settings* submenu
- Nov 3, 2018 : fixed **.BAS** Surfer scripts so they work again with Scripter 9 coming with Surfer 9 up to Scripter 16 coming with Surfer 16 Beta. Download & run updated Ray335 Scripts.exe installer on your PC where you installed our version 3.35 or 3.36 software.
- Oct 24, 2018 : decreased lower limit for *DeltatV|Interactive DeltatV|Regression over offset stations* from 3 to 2. Allows better resolved imaging of layered velocity variation with DeltatV+XTV.
- Oct 21, 2018 : decreased smallest allowed values in *Refractor|Midpoint breaks|ALT+M mapping dialog* from 3 to 2, for *Regression Receiver Count*, *Direct Wave Delta [stations]* & *Refracted Wave Offset Delta*. Allows better resolved imaging of overburden layers with layered refraction methods.
- Oct 21, 2018 : Dangeard et al. use ERT, SRT, surface waves and Poisson's ratio for time-lapse imaging of water content in river banks (UPMC Paris, 2017)
- Wodajo et al. correlate SRT and ERT with borehole data to investigate and predict causes of sand boil formations including water seepage at an earthen dam (EEGS FastTIMES Vol 23, Number 3, 2018)
- Oct 20, 2018 : check *Model|Forward modeling Settings|Improved modeling at source* for alternative initialization of traveltime grid at source. May be more accurate but may slow down modeling.
- Oct 13, 2018 : for hard-rock basement such as granite try increasing *DeltatV|Interactive DeltatV|Max. valid velocity* to 6,200 m/s and increase *Export Options|Max. velocity exported* to 5,500 m/s
- apparent CMP velocity may exceed true velocity considerably in case of strong topography or strong refractor curvature. Check this in *Refractor|Midpoint breaks* : browse CMP curves with F7/F8. Browse offset within current curve with arrow down/arrow up cursor keys. Apparent velocity is shown at bottom in status bar, together with offset (Delta) and CMP (Midpoint).
- Oct 8, 2018 : *DeltatV|DeltatV Settings|Allow regression over two CMP traces* helps with *Reduced offset 0.0 is valid trace with time 0.0* unchecked for sample profile **LINE14.** Also check *Process every CMP offset* for improved vertical resolution.
- Oct 7, 2018 : improved prompt warning about *DeltatV* artefacts in case of strong refractor curvature and strong topography curvature and for lines shorter than 500m. Recommend using *Smooth inversion*.
- Oct 7, 2018 : *DeltatV|DeltatV Settings|Allow regression over two CMP traces* allows linear regression over just two CMP-stacked first breaks for velocity determination. Uncheck for regression over at least three CMP traces resulting in less detailed overburden imaging and less artefacts.
- Oct 5, 2018 : pick branch points at receivers in *Refractor|Shot breaks*. The first break at the branch point is used for both refractors. Improves overburden layer resolution.
- Oct 5, 2018 : check *Mapping|Pick branch points between Receivers* in *Refractor|Shot breaks* to pick branch points between receivers as in version 3.35 of our software.

Version 3.35 released in Sep 2018 :

- Sep 29, 2018 : rebuilt free trial installer with latest help file and updated **.BAS** Surfer scripts
- Sep 28, 2018 : updated **AUTOTOMO.BAS**&**DELTATV.BAS** scripts work with Surfer 16 beta. Download&run updated Ray335 Scripts.exe installer on your PC where you installed our version 3.35 software.
- Sep 23, 2018 : updated PowerPoint slide show TRA9002.PPT shows how to generate layered refraction starting model with Plus-Minus refraction method&run 2D WET with **PLUSMODL.GRD** starting model
- Sep 23, 2018 : updated PowerPoint slide show TRA9002.PPT shows how to generate pseudo-2D starting model with DeltatV+XTV refraction method&run 2D WET inversion with **DELTATVXTV.GRD** starting model. See tra9002.pdf for Adobe Acrobat .pdf version of the slide show.
- Sep 5, 2018 : fixed bug in latest **AUTOTOMO.BAS** script. Download & run updated Ray335 Scripts.exe installer on your PC where you installed our version 3.35 software.
- Aug 25, 2018 : fixed assert in *DeltatV export*. Click *Ignore button* to skip Ass. **CMPHELPR.CPP** line #146.

- Aug 23, 2018 : *File|Update header data|Update Station Coordinates…* updates v0 in *Header|Station* if listed in the selected **COORDS.COR**
- Aug 23, 201 : check *File|Export data Settings|Export horizontal inline offset and v0 to .COR* to export v0 from *Header|Station* to **COORDS.COR** with *File|Export header data|Export Station Coordinates*
- Aug 22, 2018 : Ray335 Scripts.exe installs updated .BAS scripts into C:\RAY32\DAT . We now always position the Surfer plot title correctly.
- Aug 22, 2018 : with new option *WET Tomo|WET tomography Settings|Force RAM allocation* checked we now cache traveltime grids even in low-memory situations. This may result in apps swapping to disk including our own app and temporarily freeze your Windows PC especially during *WET processing* startup phase.
- Aug 19, 2018 : accept minimum velocity of 0.1 m/s in *WET starting model* **.GRD** instead of 10.0 m/s
- Aug 19, 2018 : updated help file chapter *WET tomography processing*. Use latest winhelp.exe installer.
- Aug 3, 2018 : if both *File|Import Data Settings|Allow missing traces for SEG-2* and *File|SEG-2 import settings|Receiver Coordinates specified in .DAT or .SG2 file* are checked and the SEG-2 files are missing **RECEIVER_STATION_NUMBER** or **RECEIVER_LOCATION** in the trace headers : prompt user about this, reset *File|Import Data Settings|Allow missing traces for SEG-2* and restart import
- Aug 2, 2018 : check ***File|SEG-2 import settings|Receiver Coordinates specified in .DAT or .SG2 file*** to enable import setting *File|Import Data Settings|Allow missing traces for SEG-2*
- Aug 1, 2018 : uncheck *File|Import Data Settings|Allow missing traces for SEG-2* so our SEG-2 import can deal with Seismic Source DAQLink **.SG2** files which do not specify **RECEIVER_STATION_NUMBER** or **RECEIVER_LOCATION** in the SEG-2 trace headers
- July 29, 2018 : support calling Surfer 8 and Surfer 9 again with our latest version 3.35. Unzip updated scripts in Surfer15 scripts for3 35.zip in your \RAY32\DAT directory. These updated **.BAS** scripts do not work with 3.34 or earlier versions of our software.
- July 29, 2018 : if ***CodeMeter service fails to start*** in *CodeMeter Control Center* with *Process|Start CodeMeter service* : try repairing **CodeMeter Runtime Kit** in *Windows Control Panel|Programs and Features*. If this does not help : run **regedit.exe** via *Windows Start menu*. Delete registry key **HKEY_LOCAL_MACHINE\SOFTWARE\WIBU-SYSTEMS\CodeMeter**. Leave *Registry Editor* via *File|Exit*.
- July 21, 2018 : *File|Export header data|Export refractor branches* writes refractor start/end in channel nos. to …**\LAYRTOMO\BRANCHES.BRN** ASCII file for all shots
- July 18, 2018 : for better vertical resolution check *DeltatV|DeltatV Settings|Taper velocity steps at layer interfaces*. This writes twice as many *CMP offset-elevation-velocity triples* to …**\TOMO\DELTATV.TXT** file and results in less artefacts when kriging in Surfer. Or use alternative *DeltatV|Interactive DeltatV|Export|Gridding Method* **Nearest Neighbor**. See our tutorials OT0608.pdf & jenny10.pdf .
- July 18, 2018 : write *station no.* to extra column in file written by *Grid|Export grid file to ASCII.TXT*
- July 17, 2018 : check ***Depth|Depth conversion Settings|Smooth Wavefronts*** with noisy first break picks. Uncheck for better resolution with *Wavefront method*, with exact first break picks.
- July 17, 2018 : improved *Wavefront method* interpretation with strong topography and strong refractor curvature. Allow for rays which emerge at an angle greater than 90 degrees to line topography.
- July 12, 2018 : prompt to smooth **DELTATV.GRD** starting model in Surfer if *WET inversion* fails due to invalid grid velocity
- July12, 2018 : improve prompt when shots have been extrapolated during time-to-depth conversion with *Depth|Wavefront* or *Depth|Plus-Minus* commands.
- July 12, 2018 : update forced grid cell size if changed in first three (3) decimal digits only. This happens if the grid cell count of 640,000 for Standard license or 1,280,000 for Pro license is exceeded.
- July 9, 2018 : export Plus-Minus characteristics determined during *Depth|Plus-Minus* computation, to …**\LAYRTOMO\PLUSMODL.FRN** ASCII file
- July 9, 2018 : export Plus-Minus times determined during *Depth|Plus-Minus* computation, to …**\LAYRTOMO\PLUSMODL.TMS** ASCII file
- July 7, 2018 : reduce size of Rayfract® **.EXE** executable by factoring out assert's into helper method
- July 7, 2018 : check *Depth|Depth conversion Settings|Keep extrapolated shots* to keep extrapolated **.ASC** shots in …**\EXTRAPOL** subdirectory instead of deleting them. Leave unchecked to avoid importing stale extrapolated shots during time-to-depth conversion with *Depth* menu commands.
- July 6, 2018 : when you select *Header|Profile* we now check that all added **Borehole spread/line** databases still exist on disk. If not we prompt you to restore the database from backup or reselect it.
- July 2, 2018 : more accurate, robust and repeatable *Wavefront method* computation. Don't regard previous depth interpretation for new interpretation : reset previous results in profile database.
- July 2, 2018 : export basement refractor wavefronts when running *Depth|Wavefront*, to …**\LAYRTOMO\WAVEFRONT.FRN** ASCII file

- July 2, 2018 : export overburden points determined during *Depth|Wavefront* computation, to …**\LAYRTOMO\WAVEFRNT.OVR** ASCII file
- June 18, 2018 : improved error prompt during *WET inversion* if too high or too low velocity in …**\LAYRTOMO\WAVEMODL.GRD** starting model. Recommend to increase lateral refractor smoothing in depth section window with **ALT+M** .
- June 15, 2018 : updated help file chapter *Time-to-depth conversion*. Use latest winhelp.exe installer.
- June 12, 2018 : improved error prompt if forward modeling detects invalid grid velocity due to invalid source/receiver coordinates and elevations. Prompt to fix elevations or force starting model grid limits.
- June 3, 2018 : updated help file chapter *Calling Surfer*. Use latest winhelp.exe installer.
- June 2, 2018 : updated search logic for finding **Scripter.EXE** now works with Surfer 15 and earlier Surfer versions 9 to Surfer 14. With Surfer 15 the **Scripter.EXE** is installed into Surfer 15 main directory. With earlier Surfer versions **Scripter.EXE** is installed into Scripter subdirectory.
- June 2, 2018 : for Surfer 15 select **Scripter.EXE** with ***Grid|Surfer invocation*** dialog. Press *Select* & navigate into C:\Program Files\Golden Software\Surfer 15 & select **Scripter.EXE**. Click *Open* & *OK* buttons. Now our software can invoke Surfer 15 through our .BAS scripts and Scripter.
- May 26, 2018 : in *Refractor|Offset breaks display* regard line style settings in *Mapping menu* when plotting offset-sorted curves. Map traces to refractors with **ALT+M** in *Refractor|Midpoint breaks*.
- May 26, 2018 : when unmapping traces in *Refractor|Midpoint breaks* with **ALT+U** we now regard line style settings in *Mapping menu* : gray curves, force solid curves
- May 22, 2018 : if after opening an old profile database with our version 3.35 the trace signal does not display in *Trace|Shot gather* : press **ALT+M** and increase *Trace clip* from 0.0 to 1.0 or higher. Click *Filter button* to redisplay traces.
- May 19, 2018 : don't regard receiver x/y/z in SEG-2 .DAT or .SG2 file if *File|Import Data Settings|Allow missing traces* is unchecked. Get x from *Default spread type, Header|Profile|Station spacing* and *Layout start [station no.]* instead, as previously in version 3.34 and earlier.
- May 17, 2018 : we now regard ***File|Import Data Settings|Allow missing traces*** when importing SEG-2 files. Tested with our sample **LINE14** profile with *Default spread type* 10: 360 channels and *Header|Profile|Station spacing* of 2.5m.
- May 17, 2018 : we prompt you when the *forced grid cell size* needed to be increased to stay below limit of 640,000 grid nodes for Standard license and 1,280,000 nodes for Pro license when generating the starting model
- May 16, 2018 : in *Refractor|Midpoint breaks display* we now regard the line style settings in *Mapping menu* when plotting CMP sorted curves before/after mapping traces to refractors with **ALT+M**
- May 16, 2018 : when you install multiple versions of Golden Software Surfer® on the same Windows PC then this may corrupt the previously installed Surfer version. To fix the previous installation select *Windows Control Panel|Programs and Features|Surfer … .* Click *Repair radio button* and *Next button*.
- May 13, 2018 : more robust scanning of string format subblocks when importing SEG-2 files. Helps with non-standard **OYO CORPORATION INSTRUMENT PICKWIN95 .DAT** files.
- May 10, 2018 : ***Trace clip [traces]*** shown in *Trace processing parameters dialog* displayed with **ALT+M** in *Trace|Shot gather* etc. lets you specify over how many traces the current trace is plotted with ***Clip amplitude peaks*** checked. This helps with irregular *receiver spreads* e.g. for sample **LINE14** profile.
- May 7, 2018 : when adding **Borehole spread/line** profiles to main **Refraction spread/line** profile in *Header|Profile* : adjust *Profile start offset [m]* of main profile until the x axis coordinates shown on resulting starting model and tomogram plots match the x coordinates used for added **Borehole spread/line** profiles. Keep adjusting until shot point elevation for downhole shots or receiver elevation for uphole shots matches topography of main **Refraction spread/line** profile as shown in plots. See our tutorial 11REFR.
- May 5, 2018 : enable running *DeltatV|Interactive DeltatV* and mapping of traces in *Refractor|Midpoint breaks* with ALT+M for uphole refraction survey with just one borehole. Test with SUBS19.
- May 4, 2018 : our new tutorial SUBS19 shows import and processing of uphole refraction shots
- Apr 16, 2018 : if you recorded a profile with varying receiver spacing : set ***Header|Profile|Station spacing*** to Greatest Common Divisor GCD of your spacings used. E.g. if you planted some spreads with spacing of 5m and other spreads with 3m : set *Station spacing* to 1m. Now import your **Geometrics Plotrefa .VS** or **OPTIM LLC SeisOpt** or **Interpex GREMIX .GRM** or **GeoTomCG .3DD** with *File|Import Data…* and ***Default spread type*** **10: 360 channels** or **999: 999 channels** (available with Pro license only) as usual.
- Apr 16, 2018 : to download latest drivers for green WibuKey and silver/metallic CodeMeter USB dongle go to http://www.wibu.com/downloads-user-software.html

- Apr 6, 2018 : ***Grid|Convert .CSV layer model to Surfer .GRD*** now allows for maximum of 7 layers : 6 overburden layers & one basement half-space layer when converting the **.CSV** to **.GRD** format
- Apr 6, 2018 : better error prompt if *Smooth invert* fails for *Header|Profile|Line type* **Refraction spread/line** and all shots marked as *Header|Shot|Type* **Uphole shot**
- Mar 31, 2018 : more robust search for valid velocity grid cell at tomogram boundary. Search radius of 10 cells instead of just 5. Helps with extreme topography and activated *WET blanking* options.
- Mar 31, 2018 : check ***Refractor|Mapping|Force solid picked curves*** to always draw picked curves with a solid pen. Uncheck to use a dotted pen at gaps in curve (unpicked traces).
- Mar 27, 2018 : *File|Import Data…* writing of **.HDR** batch file : correct *Shot pos. [station no.]* for *Inline offset [m]* for *Header|Profile|Line type* **Refraction spread/line** only
- Mar 26, 2018 : more robust updating of shotpoints with *File|Update header data|Update Shotpoint coordinates…* and your **.SHO** file in case adjacent stations have the same x/y/z coordinates
- Feb 28, 2018 : for help regarding Surfer issues see our .pdf reference chapter ***Calling Surfer***
- Feb 28, 2018 : to automatically update your old **.BAS** scripts as described in next two bullets and as installed with earlier versions of our software into **C:\RAY32\DAT** directory : download our new .BAS updater and backup to permanent storage. Next run **BasConvrt.EXE** on your PC where you installed these earlier versions of our software. We tested this with version 3.15 and later versions and Surfer 11/13/14/15. The updated **.BAS** scripts will continue to work with older Surfer versions.
- Feb 27, 2018 : to update **.BAS** scripts coming with version 3.21 or earlier versions of our software : replace **Overlays("Image Map")**, **Overlays("Contours")** and **Overlays("Classed Post")** with **Overlays(1)** in Windows Notepad editor. Also replace **IDocument** etc. with **Object**, see next bullet.
- Feb 25, 2018 : to make older **.BAS** scripts compatible with newer Scripter and Surfer versions : open the **.BAS** scripts in **C:\RAY32\DAT** in your favorite text editor e.g. Notepad and replace all occurrences of **IDocument, IWindow, IMapFrame, IColorMap, IContinuousColorScale, ILevels, ILevel, ILineFormat,** etc. with **Object**. This will not work with **.BAS** scripts for versions older than version 3.22 of our software.
- Feb 20, 2018 : Surfer 11 was released by Golden Software in 2012 and works fine under Window 7 64-bit. If Surfer 11 crashes under Windows 8 or Windows 10 when called from our app via **.BAS** script and Scripter : please install and use latest Surfer 15 free trial or full version instead. Select the Scripter **.EXE** in our ***Grid|Surfer invocation…*** dialog.
- Feb 13, 2018 : with opened *Refractor|Midpoint breaks display* we show a new option ***Mapping|Weigh CMP binned picks for mapping***. This option is unchecked per default, to cope with noisy traveltime picks or recording geometry errors. In earlier builds of our software we regard ***DeltatV|DeltatV Settings|Weigh picks in CMP curves*** instead. See below in Jan 29 bullet.
- Feb 2, 2018 : rebuilt winhelp.exe installer so it installs on non-U.S. English Windows versions
- Jan 31, 2018 : prompt user to delete or merge duplicate **.3DD** traces. Show duplicate rayID's in prompt.
- Jan 30, 2018 : before you import GeoTomCG **.3DD** files with *File|Import Data…* you need to merge or delete duplicate **.3DD** traces (consecutive lines with same source and same receiver coordinates). Otherwise our import routine has to assume that a new shot starts at the duplicate trace line since the **.3DD** format does not include the shot number.
- Jan 30, 2018 : when writing **.HDR** batch file in *File|Import Data…* we now add *shot inline offset* from *shot station* to *shot pos.* so our *Import Shot dialog* does not complain when running the **.HDR** batch file
- Jan 29, 2018 : export horizontal inline offset from first profile receiver to ASCII **.TXT** with *Grid|Export grid file to ASCII .TXT...* in additional column no. 5.
- Jan 29, 2018 : to get more robust traveltime field regression and better *Wavefront method* & *Plus-Minus method* output for tutorials GEOXMERC, OT0608, Val de Travers TRA02ASC and most other profiles :
  - check ***File|Import data Settings|Round shot station to nearest whole station number***
  - reimport the **.ASC** shots with *File|Import Data…*
  - reapply **.COR** station coordinate file with *File|Update header data|Update station coordinates…*
  - uncheck ***DeltatV|DeltatV Settings|Weigh picks in CMP curves***
  - remap traces to refractors in *Refractor|Midpoint breaks* with ALT+M mapping dialog
  - select *Depth|Wavefront* to rerun Wavefront refraction method
- Jan 27, 2018 : force using *spread type* with 999 channels with Pro license if required when importing extrapolated shots in *Depth|Plus-Minus* or *Depth|Wavefront* time-to-depth conversion. This helps with long lines e.g. with our GEOXMERC tutorial.
- Jan 23, 2018 : make *Header|Profile* fields *Job ID* and *Instrument* optional so you can leave them empty
- Jan 21, 2018 : instructions on how to uninstall&reinstall WibuKey driver for your green WibuKey USB dongle include screen shots with possible error messages and captions describing how to proceed

- Jan 21, 2018 : if you see error prompt ***Code Integrity check failed -> Application is terminated!*** e.g. with transparent green WibuKey USB dongle under Windows 10 64-bit with USB 3.0 port :
  - add exclusion in Windows Defender for file **`C:\RAY32\BIN\RAYFRACT32.EXE`**
  - add exclusion in Windows Defender for folder **`C:\RAY32`**
  - see our updated .pdf reference chapter *Installation and licensing*
- Jan 7, 2018 : updated paragraph *Elevation specification* in help chapter *Editing header data*. Use latest `winhelp.exe` installer.
- Jan 4, 2018 : don't delete …**`\GRADTOMO\GRADIENT.GRD,DLTAGRAD.GRD`** when importing extrapolated shots in *Depth|Plus-Minus* or *Depth|Wavefront* time-to-depth conversion
- Jan 1, 2018 : fix automated updating of *Header|Station|v0* when mapping traces to refractors in *Refractor|Midpoint breaks* display with option *Direct wave first breaks recorded* unchecked
- Dec 31, 2017 : keep shotpoint dx/dy/dz offset from *shot station* in *Header|Shot* unchanged when interpolating v0 in *Header|Station* & when importing extrapolated shots with *Plus-Minus&Wavefront*
- Dec 31, 2017 : always reset shotpoint dx/dy/dz offset in *Header|Shot* for extrapolated shots
- Dec 31, 2017 : new option *File|Update header data|Keep current directory when selecting files*
- Dec 31, 2017 : new option *File|Update header data|Select file in Profile directory*
- Dec 26, 2017 : set starting directory for file selection to **`\RAY32\<your profile name>\INPUT`** when updating headers with **`.COR/.SHO/.LST/.OYO/.GRM`** files & when selecting **`.HDR`** batch file
- Dec 25, 2017 : always initialize *Header|Shot|Source elevation* for automatically imported extrapolated shots generated during *Depth|Plus-Minus* or *Depth|Wavefront* time-to-depth conversion
- Dec 25, 2017 : *Header|Station button Force interpolate coordinates* interpolates station coordinates and shotpoint dx/dy/dz offsets&*Source elevation* even when not changing any coordinate in *Header|Station*
- Dec 25, 2017 : to force interpolation of *Source elevation* for earlier builds : select *File|Export header data|Export Station Coordinates…* and *File|Update header data|Update Station coordinates* with **`COORDS.COR`** just exported
- Dec 22, 2017 : *Header|Station button Reset v0* does not reset shotpoint offsets as long as you did not change station x/y/z coordinates in same station editor session
- Dec 21, 2017 : prompt user that shotpoint offsets will be reset when user first edits station x/y/z coordinates in *Header|Station* and then clicks button *Interpolate v0 only*
- Dec 18, 2017 : added button *Interpolate v0 only* in *Header|Station*. Use to interpolate edited *v0* without recomputing shot dx/dy/dz from inline&lateral offset from *shot station* shown in *Header|Shot*.
- Dec 16, 2017 : rebuilt free trial installer with latest help file
- Dec 16, 2017 : don't force WET setting *Limit WET velocity to maximum velocity in initial model* when user clicks radio button *Conjugate Gradient* in *WET Tomo|Interactive WET tomography* main dialog
- Dec 12, 2017 : improved description of **`.SHO`** file format in help chapter *File formats*. *UpholeTime[ms]* is listed in column 6. *Correction[ms]* is listed in column 7. These are two separate columns.
- Dec 11, 2017 : clarify in help chapter *File formats* that shot point is source position vertically projected to topography along receiver spread. Use **`.SHO file`** column 5 to specify *shot hole depth* or edit *Header|Shot|Depth* after updating shotpoints with edited **`.SHO`** file. Use latest `winhelp.exe` installer.
- Dec 7, 2017 : update shotpoint dx/dy/dz with *File|Update header data|Update Shotpoint coordinates* and selected **`.SHO`** file or when user edits inline&lateral offset from *shot station* in *Header|Shot* or when user imports data files or updates geometry with *File|Update header data* submenu commands
- Dec 7, 2017 : recompute shot dx/dy/dz from inline&lateral shotpoint offset (offset from shot station shown in *Header|Shot*) when user edits *Station spacing* in *Header|Profile*
- Dec 4, 2017 : don't reset shotpoint dx/dy/dz (offset from shot station shown in *Header|Shot*) when interpolating station coordinates & v0 in *Header|Station*
- Dec 4, 2017 : don't reset shotpoint dx/dy/dz when automatically importing extrapolated shots generated during time-to-depth conversion with *Plus-Minus* or *Wavefront* method layered refraction
- Dec 2, 2017 : updated help chapters *Seismic and header data import* and *Crosshole survey interpretation*. Added subtitles to structure text. Use latest `winhelp.exe` installer.
- Dec 1, 2017 : removed references to outdated import option *Keep same Layout start for consecutive shot trace files* in help file.
- Dec 1, 2017 : add links to Bibliography section in help chapter *Introduction*
- Nov 28, 2017 : added more sub-titles and bookmarks to .pdf help. Expanded Table of Contents.
- Nov 26, 2017 : updated .pdf help. Added bookmarks for all chapters and important topics.
- Nov 25, 2017 : updated free trial installer with latest help file
- Nov 25, 2017 : more robust detection of end of free-format string section in SEG-2 trace descriptor block. Helps with import of ***MoHo SoilSpy Rosina*** seismograph `.SG2` trace files.
- Nov 22, 2017 : updated help chapter *Installation and licensing*. Use latest `winhelp.exe` installer.

- Nov 13, 2017 : layered refraction smoothing parameter *Base filter width [station nos.]* has again default value 10. We changed the default to 8 on Apr 15, 2017; see below. *Smoothing filter width* of 10 stations can give more robust imaging of basement fault zones with *Depth|Plus-Minus* and *Wavefront* refraction methods in case of ***strong undulation of refractor elevation***. Edit with `ALT+M` in *depth section window*.
- Nov 12, 2017 : more robust determination of trace data start during import of Geometrics SeisModules `.DAT SEG-2` trace files
- Nov 6, 2017 : regard forced grid limits in *Smooth invert|Custom 1D-gradient velocity profile* when generating `SEIS32.BLN` blanking file for *Grid|Grid and image DeltatV .TXT file*
- Nov 4, 2017 : regard forced starting model grid limits specified in dialog *Smooth invert|Custom 1D-gradient velocity profile* for constant-velocity starting model
- Nov 1, 2017 : reset internal status flags after displaying inversion output in Golden Software Surfer and when reopening the profile database
- Oct 31, 2017 : always write `.FIT` file for starting model even with *WET Tomo|WET tomography Settings|Write|Store modeled picks after last iteration only* checked
- Oct 23, 2017 : forward model traveltimes over *layered refraction starting model* before imaging `.GRD` file in Surfer so RMS error in plot title is up-to-date
- Oct 23, 2017 : more robust error handling when *WET inversion* fails to complete due to bad `.GRD` etc.
- Oct 21, 2017 : more robust *DeltatV* processing with bad recording geometry or bad first break picks
- Oct 20, 2017 : our latest free trial installer and help installer install our help file correctly under foreign language Windows installations. Tested on Italian language Windows 7 64-bit system.
- Oct 19, 2017 : fixed topography blanking for *DeltatV* starting model when forcing grid limits in *Smooth invert|Custom 1D-gradient velocity profile...*
- Oct 19, 2017 : regard forced *Grid top elevation* in *Smooth invert|Custom 1D-gradient velocity profile...* when determining and plotting *1D-gradient* and *DeltatV* starting model
- Oct 16, 2017 : fixed Ass. failure for narrow *CMP curve stack width* = 3 in *DeltatV|Interactive DeltatV*
- Oct 15, 2017 : to install our free trial under latest ***Windows 10 with Creators update*** you need to
  - disable *Real-time protection* in ***Windows Defender|Virus and threat protection settings***
  - download and run our free trial installer
  - add *Exclusion* in Windows Defender for file **`C:\RAY32\BIN\RAYFRACT32.EXE`**
  - add *Exclusion* in Windows Defender for folder **`C:\RAY32`**
  - reenable *Real-time protection* in Windows Defender
  - now test starting our free trial via Windows desktop link
  - you may need to do above routine multiple times, also after restarting Windows 10
- Oct 14, 2017 : updated free trial installer with latest help file
- Oct 14, 2017 : improved description of starting model in Surfer plot title. Warn about *DeltatV* artefacts.
- Oct 14, 2017 : tested under *Windows 10 Creators update* with *Surfer 15 Beta*. Works fine.
- Sep 29, 2017 : write *WET update weighting* parameters a&b to `.PAR` & restore from `.PAR` file
- Sep 29, 2017 : our latest tutorial NGUP1_1 shows *multiscale tomography* of NGU synthetic data using *Steepest Descent* method and *Cosine-Squared* WET update weighting across the wavepath
- Sep 29, 2017 : improved error prompts if *WET inversion* fails e.g. due to bad geometry specification
- Sep 27, 2017 : Georgios Tassis et al. show detection of fracture zones in bedrock using both modeled data and field refraction data
- Sep 25, 2017 : changed default *WET wavepath width* schedule for *multirun WET*
- Sep 25, 2017 : updated help chapter *Optimize Windows*. Use latest `winhelp.exe` installer.
- Sep 22, 2017 : recommend to decrease *WET velocity smoothing* in *traveltime misfit prompt*
- Sep 22, 2017 : updated help chapter *Uphole shots and uphole picks*. Use latest `winhelp.exe` installer.
- Sep 21, 2017 : Robert Illnar shows mapping of alpine permafrost with refraction seismic interpretation using weighted ground surface temperatures (wGST)
- Sep 16, 2017 : updated help chapter *WET tomography processing*. Use latest `winhelp.exe` installer.
- Sep 15, 2017 : Georgios Tassis et al. show *WET inversion* of refraction data using ***Plus-Minus starting model*** vs. ***1D-Gradient starting model***. See also our Norcal14 tutorial.
- Sep 12, 2017 : updated help chapters *Starting up Rayfract® and profile management* & *Editing header data* paragraph *Elevation specification*. Install updated help file with latest `winhelp.exe` installer.
- Sep 6, 2017 : to rename a tomogram subdirectory in your `C:\RAY32\<profile name>` profile directory :
  - close the profile database with *File|Exit*
  - open Windows Explorer and navigate into your profile directory `C:\RAY32\<profile name>`
  - right-click subdirectory `GRADTOMO`, `TOMO`, `LAYRTOMO` or `HOLETOMO` and select *Rename*
  - type in new subdirectory name e.g. `GRAD335` and press `ENTER/RETURN` key

  - when you reopen profile `C:\RAY32\<profile name>` with *File|Open Profile…* we will recreate all of these subdirectories `GRADTOMO, TOMO, LAYRTOMO` and `HOLETOMO` if you renamed them as above
- Aug 30, 2017 : write all flags in submenu *WET Tomo|WET tomography Settings|Write* to `.PAR` file
- Aug 29, 2017 : to import `GeoTomCG .3DD` files into `Refraction spread/line` profiles :
  - check *File|Import data Settings|Import horizontal borehole survey or .3DD refraction survey*
  - check *File|Import data Settings|X coordinate is corrected for topography already*
  - select *File|Import Data…* and set *Import data type* to `GeoTomCG .3DD`
  - `.3DD` import into `Refraction spread/line` or `Borehole spread/line` resets y coordinates to 0.0
- Aug 28, 2017 : we support calling into Golden Software Surfer 15 beta version
- Aug 18, 2017 : support import of `ASCII.ASC` with ***shot/receiver elevation in feet***. If any header line of `ASCII.ASC` contains string "`feet`" or "`(ft)`" or "[ft]" without enclosing "" then shot/receiver elevation is converted from feet to meters during import with *File|Import Data…* .
- Aug 17, 2017 : more robust calling into Surfer for tomogram plotting. Delete `.RUN` files & `.OK` files once the `DELTATV.BAS` or `AUTOTOMO.BAS` script doing the plotting has completed.
- Aug 14, 2017 : write new *WET settings* to `.PAR` file for corresponding `VELOITXY.GRD` file. Restore settings from `.PAR` file with ***Grid|Reset DeltatV and WET settings to .PAR file*** .
- Aug 10, 2017 : to force use of the correct shot point elevation for offset shots positioned outside your profile's receiver range :
  - *File|Export header data|Export Station Coordinates…* and save to `COORDS.COR`
  - *File|Export header data|Export Shot Point Coordinates…* and save to `SHOTPTS.SHO`
  - edit `elevation[m]` column of `COORDS.COR` for offset shot station(s) outside profile's receiver range
  - *File|Update header data|Update Station Coordinates…* with your edited `COORDS.COR`
  - edit `shotZ[m]` and `holeDepth[m]` columns in `SHOTPTS.SHO` for offset shot station(s)
  - *File|Update header data|Update Shot Point Coordinates…* with above `SHOTPTS.SHO`
- Aug 6, 2017 : *WET Tomo|WET tomography Settings|Enable multi-core heap* does not leak memory any longer. Don't enable this for earlier versions.
- July 23, 2017 : updated free trial and included latest Surfer 14 scripts in installer
- July 22, 2017 : always show color scale in Surfer 14 plots with our latest version 3.35. Unzip updated scripts in `Surfer14_scripts_for3.35.zip` in your `\RAY32\DAT` directory. These updated scripts do not work with 3.34 or earlier versions of our software.
- July 12, 2017 : reset added borehole line database name when user clicks *Cancel button* in `seis32.dbd` selection dialog shown with *Select buttons* in *Header|Profile*
- July 12, 2017 : clear status bar at end of creation of new profile with *File|New Profile…*
- July 11, 2017 : new tutorial `KING17` shows interpretation of first breaks recorded with receivers located in three boreholes. This tutorial requires our Pro license.
- June 30, 2017 : added paragraph ***Installation of CodeMeter runtime/driver software*** in help file chapter *Installation and licensing*. Install updated help file with latest `winhelp.exe` installer.
- June 30, 2017 : check *WET Tomo|WET tomography Settings|Blank|Blank no coverage on top of borehole tomogram* in addition to blanking options *Blank no coverage after each iteration* or *Blank no coverage after last iteration* to blank on top of borehole tomogram. See updated `TUNNEL16` tutorial.
- June 28, 2017 : stop inversion early with clear error message if the starting model can't be generated due to conflict between forced grid limits and topography specified in *Header|Station*
- June 27, 2017 : don't accept *grid limits* in *Smooth invert|Custom 1D-gradient velocity profile* if these limits do not contain topography (station z coordinates) over whole profile
- June 19, 2017 : flags for ***WET blanking after last iteration*** (of current WET run) in *WET Tomo|WET tomography Settings|Blank submenu* are regarded during ***multirun WET inversion*** if *WET Tomo|Interactive WET tomography|Iterate|Blank checkbox* for respective *WET run no.* is checked only.
- June 16, 2017 : improved recovery and prompts if traces are not mapped to refractors correctly during time-to-depth conversion with *Depth menu* commands
- June 10, 2017 : in case of steep topography at line start/end you may want to configure WET blanking :
  - uncheck *WET Tomo|WET tomography Settings|Blank|Blank below envelope after last iteration*
  - optionally check or uncheck *Blank no coverage after last iteration* in same submenu
  - uncheck all other blanking options in same *WET Tomo|WET tomography Settings|Blank* submenu
  - above blanking settings may be required so shots positioned one station spacing outside first/last profile receiver are used for WET inversion

- June 10, 2017 : ***DeltatV|Interactive DeltatV|Regression over offset stations*** has new minimum value of 3 instead of former 5. A value of 3 can show more details or more noise in DeltatV inversion output in case of bad picks and geometry errors.

- June 9, 2017 : `Alt+B` shortcut in *Trace|Shot gather* shows *Automatic first break picking parameters dialog* with option *Processing|Solid color pick display* checked. For earlier builds uncheck this option.
- May 27, 2017 : describe use of SEGY trace header fields during import of `.SGY` files in new paragraph ***Use of SEGY trace header fields during import*** in help topic *Seismic and header data import*. Install updated help file with latest `winhelp.exe` installer.
- May 26, 2017 : use option *File|SEGY import settings|Force determine station numbers* if SEGY import with unchecked SEGY option *No receiver coordinates specified in .SGY file* fails due to inconsistent geometry specified in SEGY headers : e.g. varying elevation specified for same x/y coordinate pair.
- May 21, 2017 : determine *Layout start [station no.]* and *Shot pos. [station no.]* correctly when importing multiple `SEGY .SGY` trace files recorded with overlapping receiver spreads with option *File|SEGY import settings|No receiver coordinates specified in .SGY file* unchecked
- Apr 26, 2017 : *WET Tomo|WET tomography Settings|Blank|Blank no coverage after last iteration* is now checked per default
- Apr 25, 2017 : *WET Tomo|Interactive WET tomography|Edit velocity smoothing|Used width of Gaussian* has new range 0.1 .. 20.0 instead of 0.1 .. 6.0. Increase from default 1.0 for sharper filter.
- Apr 15, 2017 : layered refraction smoothing parameter *Base filter width [station nos.]* has new default value 8 instead of former 10. This can improve lateral resolution when detecting basement fault zones with *Depth|Plus-Minus* and *Wavefront* refraction methods. Edit with `ALT+M` in *depth section window*.
- Apr 8, 2017 : describe *Cosine-Squared WET update weighting* in help topic *WET tomography processing*. Install updated help file with latest `winhelp.exe` installer.
- Apr 3, 2017 : our new *WET Tomo|WET Update weighting dialog* lets you edit parameters a&b for ***Cosine-Squared weighting function***. See Chen and Zelt AGU 2012 poster Fig. 5 (a) .
- Apr 3, 2017 : set *WET Tomo|Interactive WET tomography|Ricker differentiation* to -2 to ***weight WET velocity updates with Cosine-Squared function*** instead of default -1 meaning *Gaussian weighting*
- Apr 1, 2017 : detect missing 2nd header line in `GeoTomCG .3DD` files
- Mar 31, 2017 : show *rayId* in error prompt when importing `GeoTomCG .3DD` file with bad geometry
- Mar 30, 2017 : a 2016 report by NGU (Geological Survey of Norway) compares using our *Plus-Minus method layered refraction starting model* vs. *1D-gradient starting model* for *WET inversion*.
- Mar 30, 2017 : ***vary/decrease basement refractor smoothing for our Plus-Minus method*** by 1. clicking *No button* in our *Continue with WET tomography prompt* and 2. pressing `ALT+M` in *Plus-Minus Depth Section window* to display our *Plus-Minus Model Parameters dialog*.
- Mar 30, 2017 : ***adapt our 1D-gradient starting model to layered subsurface*** by checking options *Smooth invert|Smooth inversion Settings|Allow XTV inversion for 1D initial model* and *Optimize XTV for layered starting model* before selecting *Smooth invert|WET with 1D-gradient initial model*
- Mar 30, 2017 : before importing a `GeoTomCG .3DD` survey file involving multiple boreholes (with all y coordinates = 0.0) you need to split the `.3DD` such that all traces contained in one `.3DD` are recorded with receivers located in the same `Borehole spread/line` or along the same `Refraction line` . See e.g. our tutorial `11REFR` plus `1611HOLE` tutorial.
- Mar 30, 2017 : *WET Tomo|Interactive WET tomography|Edit velocity smoothing|Maximum velocity update* now has valid range 0.01% to 30% instead of former 1% to 30%
- Mar 28, 2017 : ***WET Tomo|WET Velocity constraints|Pad polygon border*** extends the polygon border by one pixel (grid cell) in each direction when blanking velocity tomogram during *WET inversion* . This option is enabled per default to make it easier to pick the `.BLN` *blanking polygon* in Surfer.
- Mar 23, 2017 : added more figures to tutorial `tunnel16` and improved instructions
- Mar 22, 2017 : updated free trial and included latest help file in installer
- Mar 18, 2017 : describe new controls in *WET velocity constraints* and *Custom 1D-gradient velocity profile* dialogs. Install updated help file with latest `winhelp.exe` installer.
- Mar 15, 2017 : focus on *Select button* in *WET Tomo|Interactive WET tomography dialog* if no or invalid *starting model* (initial velocity model) specified
- Mar 14, 2017 : tutorial `tunnel16` shows ***imaging of tunnel excavation disturbed zone*** (EDZ) with version 3.35 of our software
- Mar 13, 2017 : unmapping traces in *Refractor|Midpoint breaks display* with `ALT+U` shortcut does not reset *CMP Stack Width* edited with `ALT+M` to default width any longer
- Mar 13, 2017 : we have changed defaults for display of first break picks in *Trace|Shot gather*. Change display settings in *Processing menu*.
- Mar 13, 2017 : obtain ***smoother DeltatV starting models with less noise/artefacts*** with non-default *DeltatV settings* as described in tutorials `OT0608` on page 3 and `GEOXMERC` on page 1. These non-default *DeltatV settings* work best for long refraction spreads/lines and dense shot spacing.

- Mar 10, 2017 : ***Depth|Depth conversion Settings|Prefer geometric velocity for Wavefront*** computes the basement refractor velocity as described by (Jones and Jovanovich, 1985). Uncheck to set basement velocity to average of forward and reverse velocity obtained from traveltimes reduced to basement refractor level (E. Brueckl, 1987). This new option is checked per default. Uncheck for lines with steep topography for more robust velocity determination.
- Mar 8, 2017 : ***WET Tomo|WET velocity constraints|Smooth polygon border*** smooths over blanking polygon border during *WET inversion*. Uncheck to strictly enforce the blanking polygon border.
- Mar 6, 2017 : more robust determination of velocity at source/receiver during *WET inversion*
- Mar 3, 2017 : *File|Export header data|Export Traces to GeoTomCG .3DD* with *File|Export data Settings|Gather traces by common receiver station* checked : regard *File|Import Data Settings|Import horizontal borehole survey or .3DD refraction survey* & *Import circular borehole survey* settings to determine `.3DD` trace sort
- Mar 3, 2017 : more robust determination of *Shot pos.[station no.]* during import of `GeotomCG .3DD` with *File|Import Data Settings|Import circular borehole survey* checked
- Feb 27, 2017 : extrapolate velocity to polygon boundary from outside when blanking inside polygon as specified in *WET Tomo|WET Velocity constraints dialog*
- Feb 26, 2017 : *WET Tomo|WET tomography Settings|Blanking|Blank no coverage after each iteration* & *Blank no coverage after last iteration* blank below covered tomogram area for *Line type* `Refraction spread/line`. For *Line type* `Borehole spread/line` we also blank above covered area.
- Feb 25, 2017 : don't plot source symbol (red triangle) on tomogram if no traces picked for that shot
- Feb 24, 2017 : `SHIFT+Z` in *Trace|Shot gather* deletes first break picks & modeled picks for current shot
- Feb 24, 2017 : `ALt+Z` in *Trace|Shot gather* deletes first break pick & modeled pick for current trace
- Feb 23, 2017 : *File|Import Data* `.HDR` file creation : write *Delay Time* and *Sample Interval* with 6 digits precision to `.HDR` . Write actual number of samples in input file to `.HDR` column *Sample Count*.
- Feb 22, 2017 : if *WET inversion* can't allocate enough RAM memory to cache all source and receiver station traveltime grids we now prompt you to install more RAM and use our Pro version
- Feb 22, 2017 : `ALT+M` in *Trace|Shot gather* etc. brings up *Trace processing parameters dialog*. Box ***Remove systematic dc offset from traces*** is now unchecked per default.
- Feb 21, 2017 : *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* now prompts you to confirm toggling this setting and deletes `...\GRADTOMO GRADIENT.GRD&DLTAGRAD.GRD`
- Feb 21, 2017 : display shotpoint and receiver coordinates with 4 digits after decimal point instead of 3. Also write coordinates to `SHOTPTS.SHO` and `GeoTomCG .3DD` with 4 digits past decimal point.
- Feb 20, 2017 : check *File|Import Data Settings| .3DD shot traces sorted by receiver offset* to improve detection of shots when importing `GeoTomCG .3DD` with multiple shots recorded at same shot point but with shifted receiver spread. Otherwise such shots are merged into one shot during `.3DD` import.
- Feb 15, 2107 : ***File|Import data Settings|Import circular borehole survey*** disables receiver spread geometry checks and does not make any assumption regarding shape of borehole spread. Use when borehole spread line loops back on itself. Check source&receiver positions on tomogram plots. Update source&receiver coordinates via *File|Update header data|Update Station coordinates* and *Update Shotpoint coordinates*. See ***Help|Contents|File formats***.
- Feb 15, 2017 : for WET inversion of data recorded with circular spread (see above bullet) you need to digitize the tunnel void boundary on our starting model plot in Surfer to generate a `.BLN` blanking file. Now select this `.BLN` in our *WET Tomo|WET Velocity constraints dialog*. Now run Smooth inversion with constant-velocity starting model. Next run *WET Tomo|Interactive WET tomography* and vary WET parameters. See ***Help|Contents|WET tomography processing***.
- Feb 15, 2017 : *WET Tomo|Interactive WET tomography|CG iterations* has new default of 10 instead of 15. *Line Search iters.* has new default of 2 instead of 3. This may make *Conjgate Gradient* more robust.
- Feb 15, 2017 : regard all databases added in *Header|Profile* when determining max. picked time needed to determine RMS error in percent
- Feb 15, 2017 : more robust import of `GeoTomCG .3DD` traces when receivers are sorted by decreasing x coordinate (horizontal hole) or decreasing z coordinate (vertical hole) in the `.3DD` file
- Feb 14, 2017 : *Smooth invert|Custom 1D-gradient velocity profile|Forced velocity* allows editing of initial velocity for constant-velocity starting model. Check box *Force constant velocity* to enforce this.
- Feb 13, 2017 : correctly display *Header|Shot|Source elevation* for *Line type* `Borehole spread/line`
- Feb 13, 2017 : allow forcing of left grid limit in *Smooth invert|Custom 1D-gradient velocity profile*
- Feb 13, 2017 : write forced grid limits to `.PAR` file when creating starting model
- Feb 10, 2017 : *Grid|Vertical plot title* plots the tomogram title vertically on tomogram. Uncheck to plot title horizontally on top of tomogram.

- Feb 9, 2017 : *File|Open Profile…* checks all borehole `SEIS32.DBD` added in *Header|Profile* if they are up-to-date. We prompt you to open any added out-of-date borehole line database with *File|Open Profile…* to revise the database.
- Feb 6, 2017 : regard for *DeltatV starting model grid* the grid limits forced in *Smooth invert|Custom 1D-gradient velocity profile*
- Feb 6, 2017 : prompt user to run Rayfract® Pro as Admin if AWE memory allocation fails
- Jan 30, 2017 : *Grid|Export grid file to ASCII.TXT…* now terminate lines in `.TXT` with <cr><lf>
- Jan 28, 2017 : ***File|Shorten stored trace length…|New trace length stored in db [ms]*** lets you specify a shorter trace length for an existing profile to reduce disk size of the database. Click *button Update traces* to revise the database. This new dialog is available for our Pro license only. *Shot delay* and *Trigger delay* are not regarded when shortening the database traces on disk.
- Jan 27, 2017 : our PowerPoint slide show shows how to interactively improve your first break picks
- Jan 27, 2017 : fixed issue with forcing grid limits in *Smooth invert|Custom 1D-gradient velocity profile*
- Jan 23, 2017 : updated help chapters *Introduction* and *Calling Surfer*. Install updated help file with our latest `winhelp.exe` installer .
- Jan 4, 2017 : support main profile *Line type* `Borehole spread/line` when adding borehole(s) with *Select button(s)* in *Header|Profile* . All profiles selected are regarded to determine tomogram limits.
- Jan 4, 2017 : regard for *Line type* `Borehole spread/line` the grid limits forced in *Smooth invert|Custom 1D-gradient velocity profile*
- Jan 4, 2017 : convert grid limits forced in *Custom 1D-gradient velocity profile* to feet with *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* checked
- Jan 4, 2017 : the *Custom 1D-gradient velocity profile* selected is used for *Line type* `Refraction spread/line` only at this time
- Jan 4, 2017 : support joint inversion of main profile shots with borehole profile(s) shots added in *Header|Profile* with *Output inversion results in Feet* checked
- Dec 28, 2016 : *Smooth invert|Custom 1D-gradient velocity profile|Grid bottom elevation* can be increased to at least 40% of depth range of *DeltatV 1D-gradient starting model*
- Dec 28, 2016 : *WET inversion* shows better error message in status bar if starting model too shallow
- Dec 27, 2016 : describe ***how to obtain elastic constants*** based on P-wave & S-wave surveys along same line in help chapter *Dynamic Poisson's ratio imaging.* Install updated help file with latest `winhelp.exe` .
- Dec 27, 2016 : don't allow selection of `1DVELO.TXT` & `1DUSER.TXT` files in *Smooth invert|WET with 1D-gradient initial model.* Prompt to copy `1DVELO.TXT` to `MYVELO.TXT` and to select `MYVELO.TXT` .
- Dec 26, 2016 : don't overwrite `1DVELO.TXT` and `1DUSER.TXT` files in *Smooth invert|WET with 1D-gradient initial model* if user selected these in *Smooth invert|Custom 1D-gradient velocity profile dialog*
- Dec 26, 2016 : let user click *OK/Cancel/Reset etc. buttons* in *Smooth invert|Custom 1D-gradient velocity profile dialog*, *WET Tomo|Interactive WET tomography dialog* and *Grid|Surfer plot Limits dialog* even if numeric field with current focus has invalid/empty value
- Dec 22, 2016 : new help file chapter ***Calling Surfer*** lists steps to try if Golden Software Scripter can't find Surfer. Install updated help file with latest `winhelp.exe` installer.
- Dec 19, 2016 : *interpolate x coordinate at stations without any picked traces* when importing Geometrics PlotRefa, Optim SeisOpt, Interpex Gremix and GeoTomCG .3DD shots
- Dec 14, 2016 : more accurate interpolation of forward modeled traveltime at receivers. Helps especially with large cell size.
- Dec 10, 2016 : Joana Santos uses SRT to obtain initial model for MASW (Univ. Lisboa, 2016)
- Dec 10, 2016 : decrease ***Refractor count*** from 2 to 1 for short lines (24 channels) in *Refractor|Midpoint breaks* with ALT+M to map basement with *Depth|Plus-Minus* or *Wavefront* layered refraction
- Dec 10, 2016 : decrease ***Base filter width*** from default 10 to 5 stations for short lines in *Depth|Plus-Minus* or *Wavefront* depth sections with ALT+M so the basement refractor can be mapped
- Dec 10, 2016 : check *Smooth invert|Smooth inversion Settings|Allow XTV inversion for 1D initial model & Optimize XTV for layered starting model* for compromise between deeper diving waves & more shallow layered refraction starting model. See our tutorial jenny10.pdf .
- Dec 5, 2016 : make error message prompts modal to dialogs so you have to confirm prompts before you can continue working with the dialog
- Nov 30, 2016 : regard *File|Export data Settings|Export coordinates in feet* when writing `.HDR` batch file in *File|Import Data…* . Unit `[m]` or `[ft]` is written to 2nd header line of `.HDR` batch file.
- Nov 30, 2016 : *File|Import Data…* regards unit `[m]` or `[ft]` in 2nd header line of `.HDR` when importing shots listed in `.HDR` batch file
- Nov 24, 2016 : improved description of *Conjugate Gradient method controls* in help file chapter ***WET tomography processing***. Install updated help file with latest `winhelp.exe` installer.

- Nov 19, 2016 : help file chapter ***Seismic and header data import*** describes our new *File|Import Data dialog*. Install updated help file with latest `winhelp.exe` installer.
- Nov 18, 2016 : disallow forcing of grid cell size for free trial in *Header|Profile* & disable option *Smooth invert|Smooth inversion Settings|Edit cell size* for free trial
- Nov 17, 2016 : fixed free trial. *Header|Profile dialog* is working again. Adding *borehole lines* to main profile is not possible in our limited functionality free trial version.
- Nov 16, 2016 : *File|Import Data…* offers new controls to ***generate a `.HDR` batch file for all matching input files in selected input directory***. Review and edit this `.HDR` batch and use for batch import.
- Nov 11, 2016 : help file chapter ***File formats*** describes our new *File|Export grid file to ASCII .TXT dialog*. Install updated help file with latest `winhelp.exe` installer.
- Nov 10, 2016 : *File|New Profile…* & *File|Open Profile…* both reset fields in *Grid|Surfer plot Limits dialog* if plot limits have not yet been saved to disk with *OK button* for this profile
- Nov 10, 2016 : reset *Grid|Export grid file dialog to ASCII .TXT dialog* as in above bullet
- Nov 10, 2016 : reset *Smooth invert|Custom 1D-gradient velocity profile dialog* as above
- Nov 9, 2016 : *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* now correctly determines the ***grid cell size in feet*** (same as Surfer *X spacing* & *Y spacing*) with checked option *Header|Profile|Force grid cell size* and using field *Header|Profile|Cell size*
- Nov 8, 2016 : *Grid|Export grid file to ASCII .TXT…* opens a new dialog which lets you select the `.GRD` input file, `.TXT` output file and optionally ***export x/y/z/velocity for cells with velocities in a specified velocity range***. This lets you easily ***build a basement contour map*** from multiple crossing 2D profiles showing elevation of "basement" with velocities in this range. Just paste all exported `.TXT` files into one `.TXT` and grid and contour with Golden Software Surfer.
- Nov 6, 2016 : added *checkbox Proportional XY Scaling* to *Grid|Surfer plot Limits dialog*. If this is checked we do not regard *X Scale* & *Y Scale* values. Edit these in *Surfer Map|Scale tab* instead.
- Nov 6, 2016 : regard *Grid|Surfer plot Limits* for *Line type* `Borehole spread/line`
- Nov 3, 2016 : install updated help file with latest `winhelp.exe` installer. Added topics for new controls in *WET velocity constraints dialog*, *Custom 1D-gradient velocity profile dialog* and *Header|Profile* .
- Nov 2, 2016 : our updated ad will be printed in EAGE NSG Dec 2016 issue
- Oct 27, 2016 : *WET Tomo|WET velocity constraints|Blank outside polygon* checkbox forces blanking outside polygon specified in selected *Surfer* `.BLN` *blanking file* overriding the *blanking flag* in header line (2nd column) of the `.BLN` . Also check box *Polygon blanking active*.
- Oct 27, 2016 : *WET Tomo|WET velocity constraints dialog* offers 4 new checkboxes for extrapolation of velocity to `.BLN` *blanking file* boundary when blanking outside polygon : *Extrapolate to top&bottom*, *Extrapolate to left&right*. Use with low velocity at shots or receivers to avoid gaps in coverage.
- Oct 21, 2016 : *File|Export header data|Export First Breaks…* writes value of -1.0 into columns *synthetic*, *residual[ms]* and *abs(residual)* if the trace has not been modeled with WET inversion
- Oct 12, 2016 : ***borehole-recorded shots can be positioned outside the receiver spread***. But the *Shot pos.[station no.]* specified during import into profile with *Line type* `Borehole spread/line` has to match an active receiver station no. used to record this shot. Once all shots have been imported go into *Header|Shot* and review&optionally edit fields *dx* and *dz* in frame *Offset from Shot Station* . Tab through dialog controls until absolute coordinate fields *x* and *z* in frame *Source Coords.* are updated. See e.g. our new `1611HOLE` tutorial. Walkaway VSP shots are recorded with 3 spreads in one borehole.
- Oct 12, 2016 : upper *File|Import Data|Select button* now shows contents of `INPUT` subdirectory of *profile directory* for current profile database.
- Oct 6, 2016 : *Smooth invert|Custom 1D-gradient velocity profile|Grid bottom elevation[m]* lets you specify the lower limit of the starting model grid. Check *Force grid limits* & click *OK* to activate this.
- Oct 6, 2016 : *Smooth invert|Custom 1D-gradient velocity profile|Left limit of grid[m] & Right limit of grid[m]* fields are enabled for our Pro license only. Check *Force grid limits box* & click *OK* to activate.
- Oct 6, 2016 : *Smooth invert|Custom 1D-gradient velocity profile|Reset limits to grid* lets you select a `VELOITXY.GRD` velocity tomogram in directories `…\LAYRTOMO` or `…\GRADTOMO` and reset above grid limits
- Sep 28, 2016 : to edit limits and scale of ***Surfer plots***
  - select our *Grid|Surfer plot Limits*
  - click *button Reset to grid* and select your final `VELOIT20.GRD` tomogram in `…\GRADTOMO` or `…\HOLETOMO` subdirectories
  - edit plot limits, min./max. velocity and x/y scale as desired
  - check box *Plot limits active* and click *OK button*
  - select *Grid|Image and contour velocity and coverage grids…* and above `VELOIT20.GRD`

- Sep 23, 2016 : our new tutorial 11REFR shows how to easily ***constrain surface-refraction tomography with VSP shots***. 1611HOLE shows *WET inversion* of the VSP shots only without refraction shots.
- Sep 23, 2016 : tutorial 11REFR compares multiscale tomography with single-run *WET inversion*.
- Sep 19, 2016 : our Pro license allows easy adding of up to four (4) *Borehole line* profiles to main profile in *Header|Profile*. The main profile can have either *Line type* `Refraction spread/line` or `Borehole spread/line` . First breaks picked for main and added profiles are used for ***joint WET inversion***.
- Sep 19, 2016 : Added *Ok/Cancel/Reset buttons* to *Header|Profile dialog*.
- Sep 16, 2016 : when adding *Borehole spread(s)* to your main profile with *Header|Profile|Select button(s)* as described below in Sep 15, 2016 bullets you may want to uncheck *WET Tomo|WET tomography Settings|Blank outside borehole tomogram*. Instead pick blanking polygon (*tomogram boundary*) in Surfer as below and use our *WET velocity constraints* option.
- Sep 16, 2016 : create the Surfer `.BLN` blanking file needed for above bullet as described in http://www.goldensoftware.com/knowledge-base/surfer/1095-how-can-i-create-a-bln-file : digitize the boundary on velocity tomogram with ***Map|Digitize*** and save to a `.BLN` file. Optionally first draw the polygon on the tomogram in an empty base layer with Surfer ***Draw|Polygon command***. See above link.
- Sep 16, 2016 : toggle the *blanking flag* in the saved `.BLN` file e.g. with Microsoft WordPad. E.g. first line `31,1` in `.BLN` means polygon with 31 points (corners), blank inside polygon. Change this to `31,0` to blank outside polygon after each WET iteration.
- Sep 16, 2016 : ***WET Tomo|WET Velocity constraints...|Select blanking file*** lets you select above Surfer `.BLN` *blanking file* after editing the `.BLN` and toggling the *blanking flag* as above.
- Sep 15, 2016 : *Header|Profile|Select button* lets you easily ***add one Borehole spread/line profile*** to main profile. Our Pro license allows adding up to four (4) *Borehole spread/line* profiles to main profile.
- Sep 15, 2016 : adding *Borehole spread/line* profile(s) to main profile as in above bullet is possible for true 2D profile databases where y coordinates are all zero 0.0 only.
- Sep 15, 2016 : when adding *Borehole spread/line* profile(s) adjust *Header|Profile|Profile start offset[m]* for main refraction profile so the horizontal X axis shown with starting model and WET tomograms matches the X axis shown for borehole tomograms.
- Sep 15, 2016 : *WET inversion* uses first breaks picked for main and all added *Borehole spread* profiles. *DeltatV* and layered refraction methods use first breaks picked for the main refraction profile only.
- Sep 15, 2016 : Smooth inversion with *constant-velocity starting model* uses first breaks picked for main profile and for added *Borehole spreads* profile(s).
- Sep 15, 2016 : plot shot and receiver symbols for added *Borehole spreads* on WET tomograms
- Sep 15, 2016 : better error prompt during *WET inversion* if velocity grid has invalid velocity values.
- Sep 15, 2016 : more robust extrapolation of velocity at top/bottom of tomogram during *WET inversion*.
- Aug 31, 2016 : write residuals to `BREAKS.LST` with *File|Export header data|Export First Breaks*
- Aug 31, 2016 : *File|Export data Settings|Write empty line to .LST after each shot* option writes blank line separating shots into `BREAKS.LST` with *File|Export header data|Export First Breaks*
- Aug 31, 2016 : *File|Update header data|Update First Breaks* skips blank lines between shots in `.LST`
- Aug 31, 2016 : complete the transaction when importing shots even if update with `IMPSHOTS.SHO` fails
- Aug 31, 2016 : updated tutorial coffey04 : how to import reversed VSP shots into refraction profile
- Aug 21, 2016 : limit WET parameter *Width of Gaussian for one period [sigma]* to max. 100.0
- Aug 19, 2016 : *File|Export data Settings|Export horizontal inline offset to .COR* optionally exports *horizontal inline offset* (from first profile receiver station) to `COORDS.COR`. Also export *weathering velocity* (v0 in *Header|Station*) and *DeltatV v0* at topography if available.
- Aug 19, 2016 : do not reset interactive WET parameters *Ricker differentiation* and *Width of Gaussian for one period [sigma]* when reopening a profile database with *Line type Borehole spread/line*
- Aug 18, 2016 : export *horizontal inline offset* (from first profile receiver station) to `COORDS.COR` .
- Aug 18, 2016 : extrapolate *custom velocity profile* to top/bottom of `GRADIENT.GRD`
- Aug 12, 2016 : install updated help file with latest `winhelp.exe` installer. Added a paragraph at end of chapter *Smooth inversion* explaining our new *Custom 1D-gradient velocity profile dialog*.
- Aug 10, 2016 : *multirun WET inversion* now works with *Wavepath frequency* above 200 Hz and *Wavepath width[ms]* smaller than 0.1 ms
- Aug 10, 2016 : when you click *Conjugate Gradient radio button* in *WET Tomo|Interactive WET tomography* we now prompt you to confirm or keep using the safer *Steepest Descent* search method
- Aug 10, 2016 : *Smooth invert|WET with 1D-gradient initial model* writes the averaged velocity vs. depth profile to `C:\Ray32\<your profile name>\GRADTOMO\1DVELO.TXT`
- Aug 10, 2016 : *Smooth invert|Custom 1D-gradient velocity profile* dialog lets you select a ***custom velocity profile*** in `.TXT` file with two columns : depth below topography and velocity. Copy above `1DVELO.TXT` to `MYVELO.TXT` and edit with Microsoft WordPad. Now select the `.TXT` file in this dialog.

Check box *Replace velocity active* and select *Smooth invert|WET with 1D-gradient initial model* to

- write the averaged DeltatV velocity vs. depth profile to file …\GRADTOMO\1DVELO.TXT
- read in your custom .TXT velocity profile specified above
- interpolate your velocity profile to all depths & use this to compute the GRADIENT.GRD with topography
- write the interpolated custom velocity vs. depth profile to file …\GRADTOMO\1DUSER.TXT
- plot the generated GRADIENT.GRD in Surfer as usual

Version 3.34 released in July 2016 :

- July 31, 2016 : uncheck *WET Tomo|Interactive WET tomography|Steepest Descent step* per default
- July 31, 2016 : reset *WET settings & blanking* when user changes *Header|Profile|Line type*
- July 30, 2016 : uncheck *WET Tomo|WET tomography Settings|Blank|Blank outside borehole tomogram* per default
- July 30, 2016 : import shots in one database transaction per import session. Write changes to database once *File|Import Data… dialog* closes only.
- July 30, 2016 : prevent changing of focus to underlying command prompt or editor window during import of shots via *File|Import Data…* . So ENTER/RETURN key is not sent to other apps.
- July 30, 2016 : optimized database settings in configuration file C:\RAY32\DAT\RDM.INI
- July 26, 2016 : more robust import routine in case your PC crashes. If you see a prompt about recovery of database press *OK button* NOT *Cancel button*. Otherwise your database will stay corrupted.
- July 19, 2016 : fixed zivko13.pdf, walkaway.pdf and vsp.pdf : uncheck *WET blanking* options
- July 18, 2016 : updated tutorial zivko13.pdf : don't blank outside borehole tomogram
- July 17, 2016 : updated tutorial walkaway.pdf : don't blank outside borehole tomogram
- July 17, 2016 : for line type *Borehole spread/line* submenu *WET Tomo|WET tomography Settings* is disabled when *Refractor|Shot breaks* is active window. Select *Window|Close All* to enable this menu.
- July 11, 2016 : our *Steepest Descent method* is more reliable and more reproducible than *Conjugate Gradient method*. Before version 3.31 *Steepest Descent* was the only method available and always implicitly selected. *Conjugate Gradient* can sometimes reach a lower *RMS error* with good data.
- July 8, 2016 : updated tutorial vsp.pdf : uncheck *WET Tomo|WET tomography Settings|Blank|Blank below envelope after last iteration* so WET completes without error message after last iteration.
- July 6, 2016 : to increase the resolution of WET tomograms try ***decreasing WET velocity smoothing*** by changing one or more *WET Tomo|Interactive WET tomography|Edit velocity smoothing* controls :
  - set ***Smooth nth iteration : n*** = to e.g. 10 instead of default 1 to smooth each 10th iteration only
  - uncheck ***Smooth velocity update*** to smooth after the update is applied to current velocity grid only
  - check ***Minimal smoothing*** instead of default ***Full smoothing***
  - check ***Gaussian*** *radio button* instead of default ***Uniform*** *radio button*
  - click *buttons Accept parameters* and *Start tomography processing*
- July 6, 2016 : tutorial sageep11_smooth50.pdf shows multiscale tomography for SAGEEP11 data with 1D-gradient starting model using *Steepest Descent* method and smoothing every 50th WET iteration
- July 6, 2016 : tutorial sageep11_16.pdf shows using 1D-gradient starting model and Conjugate Gradient method for multiscale tomography of SAGEEP11 data
- July 6, 2016 : our earlier tutorial step.pdf written in 2013 using version 3.25 of our software shows that using our ***default 1D-Gradient starting model*** with ***Smooth inversion*** and 20 or 100 WET iterations can give a good vertical resolution when imaging faults.
- July 6, 2016 : when using the *Conjugate Gradient search method* try enabling ***WET Tomo|WET tomography Settings|Blank|Blank low coverage after last iteration*** . This will blank out low-velocity edges at the bottom of the tomogram. These can occur because the *Conjugate Gradient method* combines velocity updates from all previous WET iterations (for current run) to determine the velocity update for the current iteration.
- July 6, 2016 : Häusler et al. image a fault system with ERT, SRT, reflection seismics and gravimetry.
- June 27, 2016 : *Header|Profile|Cell size[m]* is initialized to 0.5m when opening an old profile database
- June 27, 2016 : *WET Tomo|WET tomography Settings|Reset WET tomography settings to default* resets WET export settings in *Write submenu*
- June 22, 2016 : Pierre-Yves Galibert uses time-lapse SRT for estimation of water storage and residence time in the epikarst
- June 22, 2016 : L.C. Bagger et al. use SRT combined with borehole logs to image surface of limestone
- June 22, 2016 : Nayeli Lasheras Maas uses SRT&Plus-Minus method for hard-rock site investigation

- June 22, 2016 : *Mapping|Color picked traveltime curves* colors dashed lines connecting first/last picked receiver to far-offset shot point with same color as picked curve in *Refractor|Shot breaks* display
- June 13, 2016 : *Mapping|Color picked traveltime curves* now colors dashed modeled curves with same color as picked curve for each shot in *Refractor|Shot breaks* display
- June 13, 2016 : dashed modeled curves in *Refractor|Shot breaks* are displayed in transparent mode instead of opaque mode. So if the modeled and picked curves coincide the curve is shown without gaps.
- June 13, 2016 : write table with RMS error for all iterations to `VELOITXY.STX` file at end of WET run
- June 13, 2016 : *WET Tomo|WET tomography Settings|Write|Don't write RMS errors to .STX* skips creation of `VELOITXY.STX` file at end of WET run
- June 6, 2016 : faster writing of .LST and .PAR files
- June 4, 2016 : *WET Tomo|WET tomography Settings|Enable multi-core heap* allocates memory in a separate heap for each thread. This is disabled per default. Enabling this may help with many cores.
- June 4, 2016 : restore focus to main window once *File|Import Data dialog* closes after importing shots.
- June 2, 2016 : added help popup topics for new *Header|Profile* and *WET Tomo|Interactive WET tomography* controls. Run our updated installer `winhelp.exe` . Click control and press F1 function key.
- May 31, 2016 : review technical report Geophysical and Paleoseismic Investigation of the Cheraw Fault, Southeastern Colorado by Mark Zellman and Dean Ostenaa (ResearchGate, Apr 2016).
- May 30, 2016 : our Optim SeisOpt® import now correctly initializes the *Shot pos.[station no.]* in *Import shot dialog* with missing traces and first break picks adjacent to shot point.
- May 30, 2016 : in case of missing first break picks adjacent to shot point you may need to check *Smooth invert|Smooth inversion Settings|No shot position checking* for the inversion to complete.
- May 30, 2016 : *WET Tomo|Interactive WET tomography|Reset button* now resets *Edit velocity smoothing* parameters *Maximum velocity update* to 25% and *Damping* to 0.0.
- May 12, 2016 : (re)install Surfer as an administrator. Next right-click *Surfer desktop icon* and select "Run as administrator". Finally right-click *Rayfract icon* and select "Run as administrator".
- May 11, 2016 : increase *WET Tomo|Interactive WET tomography|Width of Gaussian for one period [sigma]* to 10.0 or 50.0 from default 3.0 for wide shot spacing and low-coverage lines e.g. tutorial `jenny13.pdf` to avoid artefacts at low frequency/for first few runs of *multiscale tomography* (at wide wavepath width). Or change *Ricker differentiation* from -1 [Gaussian bell] to 0 [Ricker wavelet].
- May 7, 2016 : *WET Tomo|Interactive WET tomography|Steepest Descent step* is checked per default to make *Conjugate Gradient WET inversion* more robust with wide shot spacing and noisy picks. Uncheck *Steepest Descent step* for unmodified Conjugate Gradient algorithm (Shewchuk, 1994 on page 53).
- May 4, 2016 : *WET Tomo|Interactive WET tomography|Select button* lets you select a new starting model and use this for next *WET inversion* even if the previous WET run was aborted.
- May 2, 2016 : store all *Trace|Processing* settings into profile database when *gather windows* are closed.
- May 2, 2016 : move *Surfer plot title* to the left so *Header|Profile|Line ID* can be longer and still fits.
- May 2, 2016 : *WET Tomo|WET Velocity constraints|Keep velocity unchanged below/above* work more consistently with *Conjugate Gradient WET inversion*.
- May 2, 2016 : check *WET Tomo|WET tomography Settings|Use full Steepest Descent step for Conjugate Gradient* with *Edit velocity smoothing|Maximum velocity update* below 15% to stay focused.
- Apr 18, 2016 : reset *Maximum velocity update* to 25% with *Steepest Descent button* in *WET Tomo|Interactive WET tomography…* . Set *Max. velocity update* to 15% for *Conjugate Gradient button*.
- Apr 16, 2016 : for tutorial `sageep11_16.pdf` also try *Smooth nth iteration : n = 30* and disabling *Smooth last iteration*. Also try *Steepest Descent radio button* with *Damping* 0.0 instead of *Conjugate Gradient button* with *Damping* 0.9. See added Fig. 13 and Fig. 14 in above sageep11_16.pdf .
- Apr 16, 2016 : reset *WET Damping* to 0.0 when user clicks *Steepest Descent radio button* in *WET Tomo|Interactive WET tomography…* . Set *Damping* to 0.9 for *Conjugate Gradient radio button*.
- Apr 7, 2016 : fixed issue with correction of deep uphole shots for lateral shotpoint offset with steep topography. This resulted in assertion failure in earlier version 3.34 builds in `WTHRPROC.CPP` line 606 .
- Apr 6, 2016 : made *Conjugate Gradient WET inversion* more robust by always resetting outlier velocity pixels into min./max. velocity range which you specify in *WET Tomo|Interactive WET tomography…* .
- Apr 5, 2016 : ***Model|Create Checkerboard grid…*** lets you specify magnitude and rectangular size of the checkerboard anomaly. This is enabled for our Annual Pro license only.
- Apr 5, 2016 : button *Model|Create Checkerboard grid|Select input .GRD file* prompts you to select the tomogram e.g. `C:\RAY32\LINE14\GRADTOMO\VELOIT20.GRD` on which the checkerboard anomaly is imprinted. Button *Select output .GRD file* lets you specify directory & filename for the checkered grid.
- Apr 5, 2016 : select ***Model|Model synthetic shots*** to forward model shots using your field recording geometry. Select e.g. the checkered tomogram .GRD created with *Model|Create Checkerboard grid…* .

- Apr 5, 2016 : select above …VELOIT20.GRD with *WET Tomo|Interactive WET tomography* and run e.g. 5 WET iterations to obtain VELOIT5.GRD .
- Apr 5, 2016 : in Surfer click *Grid|Math|Add Grids…* to select above VELOIT20.GRD & VELOIT5.GRD. Set "Enter a function…" to "A-B". Set *Output Grid File* e.g. to IT5DIF.GRD . and click *OK button*.
- Apr 5, 2016 : in Surfer select *File|New|Plot & Map|New|Image Map…* & above IT5DIF.GRD .
- Mar 31, 2016 : show *WET frequency* and *wavepath width* in Surfer tomogram plot title.
- Mar 31, 2016 : Matthew Hartz et al. show a 3D Geologic Model of Glacial Outwash obtained with WET tomography along seven crossing 2D profiles in MDPI Geosciences Feb 2016.
- Mar 24, 2016 : *Grid|Surfer plot Limits|Min. offset & Max. offset* accept x coordinate values outside range -100000..100000 for *Header|Profile|Line type Borehole spread/line* .
- Mar 24, 2016 : *WET Tomo|Interactive WET tomography|Edit velocity smoothing|Maximum velocity update* has new range 1..35 percent instead of former 5..35 percent.
- Mar 16, 2016 : *Header|Profile|Cell size[m]* is initialized to default 0.5m for a new profile database. For earlier version 3.34 builds initialize this yourself after creating the profile with *File|New Profile…* .
- Mar 16, 2016 : if *Header|Profile|Force grid cell size* is checked then the Surfer .GRD *X spacing (column spacing)* and *Y spacing (row spacing)* are set to *Cell size[m]* for a new starting model.
- Mar 14, 2016 : our new tutorial multistep.pdf shows robust multiscale tomography using Conjugate Gradient method for basement step model. Multirun WET inversion is made robust by configuring *WET smoothing* : limit *Maximum velocity update* to 5%, set *Damping factor* to 0.95, manual filter size etc.
- Mar 9, 2016 : during *multirun WET inversion* try *WET Tomo|Interactive WET tomography|Edit velocity smoothing|Maximum velocity update* = 5%/10%/15%/20% instead of default 25%. This can make multirun WET inversion more robust and may give better resolution at bottom of tomogram.
- Feb 26, 2016 : we now export ***DeltatV method*** results into file DELTATV.TXT instead of DELTATV.CSV . We were forced to do this to *remain compatible with Surfer 13* default import settings independent of *Region&Language formats settings* in Windows Control Panel. See below bullet Feb 22, 2016.
- Feb 26, 2016 : in Windows Explorer rename old DELTATV.CSV to DELTATV.TXT before selecting *Grid|Grid and image DeltatV .TXT file* . The .TXT format is exactly the same as the old .CSV format.
- Feb 22, 2016 : in ***Surfer 13*** select *Tools|Options|User Interface|Decimal separator|Period* for our *WET inversion* and *DeltatV method* and *Grid|Grid and image* of *DeltatV method* .CSV files to work with a ***Windows Region&Language*** setting using a Comma as decimal separator.
- Feb 18, 2016 : suppress multiple refresh of composite title bar when paging *Refractor|Shot breaks* or *Trace|Shot gather* with the other window opened. So paging is not slowed down by composite title.
- Feb 17, 2016 : ***File|Export header data|Export Residuals to .CSV*** exports the absolute difference between picked and modeled times together with shot&receiver station for all traces. This menu item is enabled for our Annual Pro license only. Picked times are corrected for lateral shotpoint offset. Grid the RESIDUAL.CSV in *Golden Software Surfer* and image the resulting .GRD grid file to obtain ***residual map***.
- Feb 16, 2016 : selecting ***Wet Tomo|Interactive WET tomography|Conjugate Gradient*** checks ***WET Tomo|WET tomography Settings|Limit velocity to maximum velocity in initial model*** . For deeper imaging of basement with *WET inversion* try unchecking option ***Limit velocity to maximum velocity in initial model*** and rerun WET inversion.
- Feb 15, 2015 : ***Window|No composite title bar in main window*** disables composite title bar, see below.
- Feb 11, 2016 : fixed first break picking for free trial in *Trace|Shot gather* with *Refractor|Shot breaks* opened. This did not work since Feb 4, 2016 with *composite title bar*, see next bullet.
- Feb 4, 2016 : always show *composite title in frame titlebar*, ending in " – [<active child title>]" .
- Feb 1, 2016 : our latest free trial installer complies with Microsoft's new *code signing requirements in force since Jan 1, 2016*. ***Internet Explorer*** under Microsoft Windows 7, Windows 8 and Windows 10 now allows downloading and running our installer without error prompt about "***invalid signature***".
- Our old free trial installer still should work under Microsoft Windows XP and Windows Vista.
- Jan 28, 2016 : to speed up *Conjugate Gradient multirun WET inversion* set *CG iterations* to 10 (default 15) and *Line Search iters.* to 2 (default 3) in ***WET Tomo|Interactive WET tomography***. This may make WET inversion more robust and can result in less artefacts.
- Jan 28, 2016 : try changing ***WET Tomo|Interactive WET tomography|Degree of differentiation of Ricker wavelet*** from its default value of -1 (Gaussian) to 0 (Ricker wavelet) for multiscale tomography. This can make a difference especially at low frequency = wide wavepath width.
- Jan 23, 2106 : our app closes during ***Windows 8.1*** & ***Windows 10*** shutdown without message about "unusual termination request". Ignore this prompt in version 3.33 and earlier or close via *File|Exit* .
- Jan 16, 2016 : show ***RMS error in ms*** in Surfer plot title after *RMS error in %* .
- Jan 16, 2016 : export to BREAKS.LST file two more columns with *first break corrected for shot point offset [ms]* and *shot position [station no.]* .

- Jan 16, 2016 : we show in `.FIT file` & Surfer plot title the ***RMS error between modeled & offset-corrected picks***. For *WET inversion* & *forward modeling* picks are corrected for *lateral shot offset*.
- Jan 16, 2016 : increase maximum *half width* of *WET smoothing filter* from 200 to 250 columns.
- Jan 16, 2016 : run child dialogs of *DeltatV main dialog* and *WET main dialog* modally relative to these main dialogs so they are disabled while the child dialogs are open.
- Jan 14, 2016 : ***WET Tomo|Interactive WET tomography|Select*** *button* checks dimensions of selected Surfer .GRD starting model and prompts user with error dialog. In version 3.33 the selected .GRD grid file is validated once the user clicks *button Start tomography processing* in main WET dialog only.
- Jan 11, 2016 : ***Header|Profile|Cell size[m]*** lets you edit the grid cell size. Check *box Force grid cell size* to force the cell size to your edited size when starting model grids are (re)generated next time.
- Jan 11, 2016 : with ***Header|Profile|Force grid cell size*** not checked we update *Header|Profile|Cell size[m]* to the default cell size determined next time a new starting model is generated. You can increase or decrease the default cell size with options in *menu Smooth invert|Smooth inversion Settings.*
- Jan 11, 2016 : ***WET Tomo|WET tomography Settings|Store modeled picks after last iteration only*** saves modeled traveltimes in RAM memory between WET iterations. Modeled picks are stored permanently on disk and in the profile database after the last iteration only to speed up *WET inversion*.
- Jan 11, 2016 : if ***WET Tomo|WET tomography Settings|Don't reciprocally average modeled picks during WET inversion*** is checked then we reciprocally average modeled traveltimes in direction source-receiver and receiver-source once *WET inversion* has ended only. May decrease accuracy of WET modeled picks, wavepaths and tomograms. Uncheck to average picks during each iteration.
- Jan 11, 2016 : when importing shots into *Header|Profile|Line type* ***Borehole spread/line*** we now reset the y coordinate for all source and receiver positions to 0. This ensures a 2D survey geometry.
- Jan 11, 2016 : our Annual Pro license now reads and writes Surfer .GRD grid files with up to 20,000 columns instead of maximally 16,000 columns. Our Standard license allows up to 8,000 columns.
- Dec 31, 2015 : ***File|Import Data|Import data type Geometrics Plotrefa .VS*** import again allows missing traces in .VS input file(s). This works also in version 3.32 but is broken in version 3.33.
- Dec 28, 2015 : ***Grid|Reset DeltatV and WET settings to .PAR file*** resets multirun WET starting model to original starting model name now stored at end of .PAR file.
- Dec 22, 2015 : faster writing of .GRD files to disk during *WET inversion* if output in feet with starting model in feet.
- Dec 22, 2015 : for layered WET inversion convert the layered refraction starting model `C:\RAY32\<your profile>\LAYRTOMO\PLUSMODL.GRD`, `WAVEMODL.GRD` or `CMPMODL.GRD` to feet with ***Grid|Convert grid file between feet and meters...*** before starting WET inversion in *WET Tomo menu*.
- Dec 17, 2015 : reactivated ***Header|Station|Correct x*** button. This was disabled for version 3.33 but works for version 3.32.
- Dec 17, 2015 : in version 3.33 export coordinates with ***File|Export header data|Export Station Coordinates***. Reimport `COORDS.COR` with *File|Update header data|Update Station Coordinates|Adjust X coordinate to fit Y coordinate and elevation* checked instead of using *Header|Station|Correct x*.
- Dec 17, 2015 : ***File|Update header data|Update Station Coordinates|Adjust X coordinate to fit Y coordinate and elevation*** is regarded in version 3.33 when interpolating x coordinate in *Header|Station*.
- Dec 17, 2015 : use *File|Update header data|Update Station Coordinates|Reset parameters button* in version 3.33 to enable x coordinate editing in *Header|Station* without automatic adjustment&correction.
- Dec 15, 2015 : ***WET Tomo|Interactive WET tomography|Reset*** deactivates multirun WET. Reactivate with button ***Iterate*** : check box ***WET runs active*** and click OK button.
- Dec 15, 2015 : ***WET Tomo|Interactive WET tomography|Conjugate Gradient*** sets ***WET damping factor*** to 0.9 from default 0.0. This ensure a more robust Conjugate Gradient method WET inversion.
- Dec 14, 2015 : store active multirun WET settings to .PAR file, restore from .PAR .
- Dec 14, 2015 : faster writing of .PAR files, flush formatted lines from buffer to disk file.
- Dec 12, 2015 : write new Smooth invert & WET settings to .PAR file & restore from .PAR .
- Dec 11, 2015 : ***WET Tomo|Interactive WET tomography|Min. velocity*** sets the minimum velocity in the resulting tomogram. ***Max. velocity*** sets the maximum velocity.
- Dec 8, 2015 : ***Grid|Image and contour velocity and coverage grids...*** now regards a selected .PAR file with different name than the selected velocity .GRD file when calling Surfer.
- Dec 3, 2015 : enforce again during data import into ***Line type Borehole spread/line*** that *Shot pos. [station no.]* is set to active *receiver channel [station no.]*. This check was disabled for version 3.33.
- Dec 3, 2015 : fixed tutorial `CFE15.pdf` : disable shot position checking against traveltime curve before `ASCII.ASC` import.

- Nov 30, 2015 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Uniform central row weight [1..100]*** lets you give more weight to central row of uniform smoothing filter. This can help with layered subsurface setting to improve contrast between layers.
- Nov 30, 2015 : precompute ***Gaussian smoothing kernels*** with *WET Tomo|WET tomography Settings|Scale WET filter height* checked. Gaussian smoothing now runs as fast as uniform smoothing.
- Nov 28, 2015 : further speed up WET inversion by eliminating unnecessary waiting at `#pragma omp critical` sections.
- Nov 27, 2015 : *WET grid smoothing* uses multiple CPU cores in parallel to speed up WET inversion.
- Nov 19, 2015 : ***WET Tomo|Interactive WET tomography|or RMS error does not improve for n =*** has new default of 50 iterations instead of current 10 for ***Conjugate Gradient search method***. Prevents multirun Conjugate Gradient WET inversion to stop runs early without any warning.
- Nov 18, 2015 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Damping [0..1]*** lets you specify the ***damping factor a***. The velocity tomogram for the current iteration is damped with previous iteration tomogram : **V(i+1)=a*V(i)+b*V(i+1); a+b=1; b=1-a .** This makes WET more robust especially with bad picks and when using our new multirun WET / ***multiscale tomography*** option.
- Nov 7, 2015 : ***File|Import Data*** has new edit fields ***Default sample interval [msec]*** and ***Default sample count***. Use these fields for shot files without seismograph traces e.g. for `ASCII.ASC` and `Interpex Gremix .GRM` to determine the time scale in *Trace|Shot gather* and *Refractor|Shot breaks*.
- Nov 7, 2015 : ***File|Import Data*** has new ***button Reset import***.
- Nov 7, 2015 : to prevent continuous redisplay of *Refractor|Shot breaks* shut down ***Windows Task Manager*** or other third-party apps. These apps seem to cause repaint messages sent to our app.
- Nov 5, 2015 : ***File|Import Data*** allows importing `ASCII.ASC` files with up to 999'000 traces (1000 shots into 999 channels) for our Annual Pro Subscription license.
- Oct 25, 2015 : ***Grid|Surfer plot Limits*** displays all field labels completely under Windows 10.
- Oct 25, 2015 : ***WET Tomo|Interactive WET tomography|Iterate*** shows run no. in first column under Windows 10.
- our new tutorial `CFE15.pdf` shows ***multiscale tomography of tunnel overburden***.
- Remi Valois et al. show time-lapse models of epikarst profiles comparing SRT with ERT in EAGE NSG Feb 2016. SRT allows for deeper imaging due to saturated overburden layer.
- Douglas B. Desper et al. show water-table depth estimation using our *WET inversion* in EAGE NSG Oct 2015.

Version 3.33 released in Sep 2015 :

- ***WET Tomo|Interactive WET tomography|Iterate button*** shows new ***dialog Edit WET runs***. This dialog lets you specify *wavepath width* and *WET iteration count* for ***multirun WET inversion*** with up to 10 WET runs as shown in our tutorial `SAGEEP11_13.pdf` . This multiscale tomography better resolves anomalies especially with noisy data. Once you click *Start tomography processing button* these WET runs are done automatically, using your schedule. Directories `WETRUN1` up to `WETRUN10` are created below the subdirectory holding the initial model selected for interactive WET. The final model `VELOITx.GRD&PAR` of the previous run `y` is copied from `WETRUNy` into the `WETRUNz` subdirectory for the next run `z=y+1` and is renamed to `RUNyITx.GRD&PAR`. This is the starting model for the next run.
- Sep 29, 2015 : updated rayfract.pdf reference converted from latest help file version.
- Sep 27, 2015 : ***WET Tomo|Interactive WET tomography|Iterate|Blank after each run*** is unchecked per default for version 3.33. Try checking this box before starting *multirun WET* for refraction profile (see above bullets) to avoid imaging artefacts at tomogram edges.
- Aug 25, 2015 : when our Pro version shows prompts "OpenPolicy : Access is denied" and "Error : Cannot enable the SE_LOCK_MEMORY_NAME privilege. Failed with error 1300 : Not all privileges or groups referenced are assigned to the caller." under Windows 10 64-bit :
  - click *Ok button* to confirm the prompts. WET inversion will continue without access to RAM memory above 4 GB limit.
  - once WET inversion is complete select *File|Exit*
  - right-click Rayfract® desktop icon and select *Properties*
  - click *button Advanced* and check *box Run as administrator*
  - click *buttons Ok* / *Apply* / *Continue* / *Ok*
  - restart Windows 10
  - startup our app via desktop icon as usual. Now WET inversion can use up to 64 GB of RAM.

- Aug 24, 2015 : updated help file chapters Commands, Introduction, Overlapping receiver spreads, WET tomography processing and Crosshole survey interpretation. Use our updated installer winhelp.exe .
- Aug 21, 2015 : ***Window|Show prompts on top of other applications*** is checked whenever you (re)open a profile database. This restores the behaviour prior to Oct 27, 2014. See below.
- Aug 20, 2015 : fixed issue where ***WET continuation prompt*** during time-to-depth conversion with ***Depth|Plus-Minus*** & ***Depth|Wavefront*** methods disappears behind main app window when clicking on Surfer plot showing layered starting model and then clicking on our app again. This only happened under Windows XP, worked fine under Windows 7, 8 and 10 even without this fix.
- Aug 14, 2015 : tested version 3.33 under Microsoft Windows 10 64-bit. No problems found.
- Aug 12, 2015 : when running Windows in Parallels Desktop virtual machine on iMac, restore keyboard language mapping after switching from OSX to Windows with taskbar language symbol EN, FR etc.
- Aug 10, 2015 : if ***shot depth*** is missing in ***Interpex IXRefraX .GRM*** files we now regard default depth specified in ***File|Import Data dialog*** when importing .GRM shots or updating shots from .GRM file.
- Aug 10, 2015 : ***File|Update header data|Update from Gremix .GRM files...*** does improved matching of *receiver positions* specified in .GRM file to *receiver station numbers* in current profile database.
- Aug 6, 2015 : ***Grid|GS CENTERED font for receivers*** forces use of font `GS CENTERED` symbol no. 48 for plotting of receivers. Uncheck to use font `GSI Default Symbols` symbol no. 102.
- Aug 2, 2015 : Scripter13 scripts.zip contains updated `AUTOTOMO.BAS` and `DELTATV.BAS` scripts for Surfer 13. Copy these .BAS files into `C:\RAY32\DAT` directory.
- Aug 2, 2015 : updated Surfer scripts `AUTOTOMO.BAS` and `DELTATV.BAS` disable ***Hill Shading*** when run with Surfer version 13. These scripts still work with earlier Surfer and Scripter versions.
- Aug 2, 2015 : Surfer scripts `AUTOTOMO.BAS` and `DELTATV.BAS` use font `GS CENTERED` symbol no. 48 for plotting of receivers and font `GSI Default Symbols` symbol no. 21 for plotting of sources in `Sub Create_And_Configure_ShotPostMap`.
- Aug 2, 2015 : Surfer12 scripts.zip holds previous versions of above Surfer scripts.
- July 29, 2015 : updated winhelp.exe help installer now recognizes Microsoft Windows 10.
- July 27, 2015 : to ***increase max. imaged depth for single-spread profiles*** please
  - uncheck ***WET Tomo|WET tomography Settings|Blank below envelope after last iteration***
  - increase ***WET Tomo|Interactive WET tomography…|Wavepath width*** to 20%, 30% or even 50%
  - click button ***Start tomography processing*** and confirm prompts as usual
  - or use overlapping receiver spreads so *profile-internal far-offset shots* are used for *WET inversion*
- July 27, 2015 : increasing the *WET wavepath width* as described in above bullet corresponds to lowering the modeled signal frequency. So resolution decreases but maximum imaged depth increases. See also our SAGEEP14 expanded abstract and our new tutorial which shows how to activate multiscale tomography with ***Iterate button*** in ***WET Tomo|Interactive WET tomography…***
- July 27, 2015 : ***far-offset shots*** located more than one *Station spacing* outside first/last profile receiver are not used for *2D WET inversion*. These shots are regarded for layered refraction with *Plus-Minus* and *Wavefront* methods and for *1.5D DeltatV* method used for the *1D-gradient starting model*.
- July 24, 2015 : Scripter13 scripts.zip contains updated `AUTOTOMO.BAS` and `DELTATV.BAS` scripts for Scripter version 5.0.21.488 coming with Surfer 13. Copy these .BAS files into `C:\RAY32\DAT` directory.
- July 20, 2015 : with new ***Surfer 13*** please uncheck ***Hill shading*** in Surfer `Object Manager > Image` for velocity tomograms and wavepath coverage plots obtained with our software.
- July 20, 2015 : if geophones are not plotted any longer or shown with different symbol on velocity tomogram after Surfer upgrade please select ***Symbol Set*** `GS CENTERED` and ***Symbol Number*** 48 in Surfer `Object Manager > Classed Post > Classes > Edit Classes` for class 2. Increase ***Size*** to 0.2 inches.
- July 13, 2015 : regard *shot and receiver elevations* in `ASCII.ASC` in ***File|Import Data…*** when importing into ***Line type Borehole spread/line***.
- July 10, 2015 : ***Header|Profile|Units*** change to ***feet*** now updates ***Station spacing*** field display correctly even when not all other required fields have been edited yet, for a new profile database.
- July 7, 2015 : ***File|Import Data…|Import data type*** can now be set to ***ASCII column format*** for ***Line type Borehole spread/line*** selected in *Header|Profile…* before importing any shots. We disregard shot elevation and receiver elevation in `ASCII.ASC` when importing into *Borehole spread/line*. After import use *File|Export header data|Export Station Coordinates…* to `COORDS.COR` and *…|Export Shotpoint Coordinates…* to `SHOTPTS.SHO` . Then update x/y/z in columns 2, 3 & 4 of `COORDS.COR` and `SHOTPTS.SHO` using e.g. Microsoft WordPad text editor. y coordinate is always 0 for *Borehole spread/line*. Now use *File|Update header data|Update Station Coordinates…* and *…|Update Shotpoint coordinates…* with edited `COORDS.COR` & `SHOTPTS.SHO` to update trace headers in currently opened profile database.

- July 7, 2015 : ***File|Update header data|Update Station Coordinates…|Maximum tolerance [percent]*** is now 500 percent per default for ***Line type Borehole spread/line***. For type ***Refraction spread/line*** this is still 25 percent per default since determination of refractor velocity uses station numbers of receivers. WET inversion uses x/y/z coordinates only so station numbers can be inconsistent regarding ***Header|Profile|Station spacing [m]*** value.
- July 7, 2015 : ***Smooth invert|Smooth inversion Settings|No shot position checking*** lets you skip checking of shot position against shot-sorted traveltime curve minimum. This can help for uphole shots with strong topography.
- July 2, 2015 : fixed crash in ***File|Import Data…*** if no shot files found. For older versions restart our app, click upper ***Select button*** and reselect one file to be imported. Now click ***Import Shots… button***.
- June 25, 2015 : fixed ***polygon blanking with mask grid velocity*** if no *blanking velocity* specified in *polygon header line* in `.BLN` *blanking file*.
- June 24, 2015 : allow ***blanking percentage*** range `0..500` in 4th column of ***polygon header line*** in `.BLN` *blanking file*.
- June 24, 2015 : updated help file chapter ***WET tomography processing***. In last paragraph we describe new velocity constraints options. Download and run installer `winhelp.exe` to update your installation.
- June 22, 2015 : fixed assertion failure when blanking polygon without resetting velocity.
- June 17, 2015 : convert *blanking file* from feet to meters for WET inversion. If the *WET initial model* `.GRD` is in feet (according to matching `.PAR` file) then assume that the `.BLN` *blanking file* is in feet too.
- June 16, 2015 : convert *mask grid* from feet to meters for WET inversion. See next bullet.
- June 15, 2015 : ***WET Tomo|WET Velocity constraints...|Select mask grid file*** lets you select a Surfer `.GRD` *mask file*, a 2D grid with same dimensions (column count & row count) as *WET initial model* `.GRD` file. The *blanking polygon* in the `.BLN` *blanking file* selected with ***Select blanking file*** is reset to velocities from the mask file during WET inversion. *Blanking percentage* (see next bullet) is regarded.
- June 11, 2015 : specify ***percentage*** value `0..100` in 4th column of polygon header line in `.BLN` *blanking file*. This percentage specifies how much the tomogram velocity may deviate from ***blanking velocity*** specified in 3rd column of `.BLN` blanking file. If the tomogram pixel velocity deviates more than maximum allowed deviation then the pixel velocity is reset to maximum allowed deviation.
- June 10, 2015 : fixed WET velocity update smoothing : reset update to zero in *blanking polygon*.
- June 3, 2015 : enforce valid parameter values in ***Grid|Surfer plot Limits...*** .
- June 3, 2015 : ***WET Tomo|WET Velocity constraints...|Select blanking file*** lets you select a Surfer `.BLN` *blanking file* specifying a polygon to be kept at constant velocity during WET inversion.
- June 1, 2015 : improved detection of invalid `.BLN` *blanking file* in ***Grid|Blank polygon area in grid...*** . Blank selected `.GRD` with valid `.BLN` only.
- June 1, 2015 : http://www.goldensoftware.com/knowledge-base/surfer/1957-fix-available-for-gsdraw-error-1-generic-error describes how to fix Surfer error ***GS Draw error (1): GenericError*** when plotting tomograms via Scripter.
- May 31, 2015 : fixed assertion `is_directWave ? refractor == 0 : true` during Smooth inversion.
- May 28, 2015 : ***Grid|Blank polygon area in grid...*** works with `.GRD` specified in feet instead of meters. Just make sure the Surfer `.BLN` *blanking file* is specified in feet also.
- May 21, 2015 : ***Grid|Blank polygon area in grid...*** resets `.GRD` pixels to be blanked to velocity value specified in 3rd column of polygon header line in selected `.BLN` *blanking file*. Edit this blanking velocity with your favorite text editor e.g. Microsoft WordPad. E.g. `.BLN` polygon header line `31,1,500` means polygon with 31 points (corners), blank inside polygon, reset blanked pixels to 500 m/s.
- May 20, 2015 : ***Grid|Blank polygon area in grid...*** asks you to select a velocity tomogram `.GRD` file `VELOITXY.GRD` or `GRADIENT.GRD` or `DELTATV.GRD` in directory `\RAY32\<your profile name>\GRADTOMO` or `…\LAYRTOMO` or `…\TOMO`. Next you are prompted to select a Surfer format `.BLN` *blanking file*. Once you have selected these two files we blank the `.GRD` file either inside the polygon specified in the `.BLN` file or outside this polygon depending on setting of flag in polygon header line in the `.BLN` file.
- May 20, 2015 : create the Surfer `.BLN` blanking file needed for above bullet as described in http://www.goldensoftware.com/knowledge-base/surfer/1095-how-can-i-create-a-bln-file : digitize the boundary with ***Map|Digitize*** and save to a `.BLN` file. Optionally first draw the polygon on the velocity tomogram in an empty base layer with Surfer ***Draw|Polygon command***. See above link.
- May 12, 2015 : improved help file chapter ***Mapping traces to refractors***. Download and run installer `winhelp.exe` to update your installation.
- May 11, 2015 : enforce max. limit higher than min. limit for offset/elevation/velocity range specified in ***Grid|Surfer plot Limits…*** .
- May 8, 2015 : increased length of static text fields in new dialogs so labels display completely on old Toshiba A40 portable runningWindows XP.

- May 5, 2015 : ***Grid|Velocity vs. Two-way time...*** now writes the velocity-vs-two-way-time function at a sample interval of 1ms instead of 5ms. Also we write the function at every 2nd CMP station instead of every 5th CMP station. And we write *horizontal inline offset* & *elevation* into .TWT columns 2 & 3.
- May 5, 2015 : ***Grid|Velocity vs. Two-way time...*** regards your setting of *Smooth invert|Smooth inversion Settings|Output inversion results in Feet* and writes column headers to first line of .TWT file.
- May 1, 2015 : ***Grid|Surfer plot Limits...*** edits ***Color Scale settings*** for Surfer plots : *height* of scale bar in inches or cm, *velocity label interval* in m/s or ft/sec. and *coverage label interval* in paths/pixel.
- Apr 29, 2015 : ***Grid|Surfer plot Limits...*** lets you edit min./max. *offset* and *elevation* and min./max. *velocity*. Also you can edit *x scale length* and *y scale length* in inches or in cm. Check ***Plot limits active*** and click *Ok button* to use these limits in future calls into Surfer for plotting of velocity tomograms. These limits will not be regarded when plotting a starting model just generated. Call Surfer via ***Grid|Image and contour velocity and coverage grids...*** and select the `VELOITXY.GRD` or `GRADIENT.GRD` or `DELTATV.GRD` in directory `\RAY32\<your profile name>\GRADTOMO` or `…\LAYRTOMO` or `…\TOMO`. These limits are regarded during WET inversion multiscale tomography. This makes it easier to compare tomograms from multiple WET runs using varying WET parameter settings.
- Apr 28, 2015 : ***Grid|Surfer plot Limits…|Reset to grid button*** asks you to select a `VELOITXY.GRD` file and next resets plot limits displayed to limits stored in the header of this Surfer format .GRD file.
- Apr 19, 2015 : improved error messages when imaging of Surfer .GRD fails and when conversion of layered model .CSV to .GRD format fails.
- Apr 18, 2015 : export topography and weathering velocity to layered model .CSV for shot positions outside active receiver range. These shot positions are regarded when converting the .CSV to Surfer .GRD format.
- Apr 17, 2015 : with ***Grid|Stack shot labels at same offset*** checked we now vertically stack shot numbers for all shots positioned at same shotpoint when plotting tomograms.
- Apr 13, 2015 : for long profile with more than 50 receiver stations uncheck ***DeltatV|DeltatV Settings|Limit DeltatV velocity exported to maximum 1D-gradient velocity*** per default.
- Apr 13, 2015 : disable *File|SEG-2 import settings* and *File|SEGY import settings* if no profile opened.
- Mar 29, 2015 : *File|New spread type*, *File|Import spread types* and *File|Export spread types* works without an open profile. For earlier versions first open a profile database e.g. LINE14 sample profile.
- Mar 28, 2015 : disregard polyline when automatically picking first breaks with ALT+B if user unchecks ***Processing|Enable polyline picking*** in *Trace|Shot gather*.
- Mar 28, 2015 : reset multirun WET settings to defaults when updating profile database to version 3.33.
- Mar 16, 2015 : updated help file chapters Seismic and header data import & File formats. Download and run updated `winhelp.exe` installer.
- Mar 14, 2015 : added new section ***.CSV layered model file*** to help file chapter File formats.
- Mar 11, 2015 : updated help file chapter Introduction.
- Mar 5, 2015 : improved blanking outside borehole tomogram. This assumes that all receivers are located in one hole and all sources are in the other hole. We determine the *bounding polygon* as in http://stackoverflow.com/questions/217578/point-in-polygon-aka-hit-test .
- Mar 5, 2015 : ***WET Tomo|WET tomography Settings|Blank outside borehole tomogram*** enables/disables above borehole tomogram blanking.
- Feb 23, 2015 : updated help file. Download and run updated `winhelp.exe` installer on your PC. This also installs `windows.hlp` into `\Ray32\help` directory to ***prevent Windows help from crashing*** our app when no help topic is available for a specific dialog control.
- Feb 18, 2015 : regard setting of *Blank checkboxes* in Edit WET runs dialog during WET.
- Feb 17, 2015 : added columns ***Freq. [Hz]*** and ***Width [ms]*** to above *Edit WET runs dialog*. *Freq.* can be edited in addition to ***Width [%]*** for every run. *Width [ms]* is read-only and is computed as (1.0/frequency) * width/100.0 * 1000.0 . This value is used to compute *wavepaths* for WET inversion.
- Feb 11, 2015 : ***toggle distance unit between feet and meters*** in *Header|Shot* with *Units combobox*. All distance parameters in all parameter dialogs can now be displayed and edited in feet.
- Feb 5, 2015 : improved error message if ***invalid Shot pos. [station number]*** specified during shot import into *borehole spread/line*. Set *Shot pos. [station number]* to nearest active receiver station. Set *Source x* and *Source z* to true shot coordinates. Our import routine then sets *Shot dx* and *Shot dz* in *Header|Shot* to offset of true shot coordinates from *Shot pos. [station number]*.
- Feb 4, 2015 : added column with ***Blank checkboxes*** for each run in above ***Edit WET runs dialog***. These are updated when you toggle buttons ***Blank after each run*** and ***Blank after last run***. Each run's checkbox can be toggled individually by left-clicking it. These boxes override *WET Tomo|WET tomography Settings|Blank below envelope after last iteration* during multirun WET inversion.

- Feb 2, 2015 : added buttons ***Blank after each run*** and ***Blank after last run*** to *Edit WET runs dialog*. These can be used to toggle ***Blank checkboxes*** for each/for last run, see above bullet.
- Feb 2, 2015 : ***SEGY import*** now starts a new shot when trace header field ***EnergySourcePoint*** changes. For previous software version a new shot is started when ***FieldRecord*** changes between traces only.
- Jan 28, 2015 : updated help file chapter Time-to-depth conversion showing automatic WET inversion using the layered refraction starting model just obtained.
- Jan 27, 2015 : updated help file chapter WET tomography processing documenting new multirun WET dialog. To update your Rayfract® installation download winhelp.exe installer and run on your PC.
- Jan 26, 2015 : increase *WET Tomo|Interactive WET tomography|Wavepath frequency* for more narrow wavepaths in single-run or multirun WET inversion. E.g. for crosshole survey increase ***WET frequency*** from default 50 Hz to 100 Hz or 200 Hz. Visually determine dominant period [in seconds] of your trace signal in *Trace|Shot gather*. Next determine dominant frequency = 1/period. ***WET wavepath width*** [in seconds] is specified in percent of one period with period = 1/*WET frequency*.
- Jan 26, 2015 : to always run Rayfract® as administrator use option six in sevenforums.com tutorial. This helps with issues when calling Golden Software Surfer via their Scripter utility and with our Pro license when accessing RAM memory above 4 GBytes limit via Microsoft AWE.
- Jan 19, 2015 : allow multirun WET inversion for Standard license not just Pro license.
- Jan 12, 2015 : added ***checkbox WET runs active*** to above *Edit WET runs dialog*. Check this box to start WET runs with *Start tomography processing button*.
- Jan 12, 2015 : added ***checkbox Plot runs in Surfer*** to above *Edit WET runs dialog*. Check this box to show the final iteration of each WET run in Golden Software Surfer during tomography processing.
- for easier comparison of Surfer plots for above WET runs uncheck ***WET Tomo|WET tomography Settings|Update imaged grid depth*** before starting tomography processing.
- uncheck ***WET Tomo|WET tomography Settings|Blank below envelope after last iteration*** to prevent blanking of tomogram passed from previous WET run to next WET run and to ensure deeper imaging.
- set WET smoothing to ***Minimal smoothing*** before starting above multirun WET inversion for best resolution with final few runs. Multirun inversion is more robust than default single-run WET inversion so requires less smoothing.
- Jan 12, 2015 : added ***checkbox Prompt run misfit*** to above *Edit WET runs dialog*. Check this box to prompt you with *traveltime misfit* after each WET run. Uncheck to skip these prompts.
- Jan 12, 2015 : added ***read-only field Runs completed*** to above *Edit WET runs dialog*. This shows the number of the last WET run completed with previous tomography processing.
- Jan 12, 2015 : added ***read-only checkbox All runs completed*** to above *Edit WET runs dialog*. This is set to false at start of tomography processing and set to true after all WET runs have completed.
- Jan 12, 2015 : added ***read-only field Current run no***. to above *Edit WET Runs dialog*. This shows the number of the WET run being processed when previous tomography processing ended or was stopped.
- Jan 12, 2015 : added ***checkbox Resume current run*** to above *Edit WET Runs dialog*. Check this box to resume WET run number ***Current run no.*** during next tomography processing if ***All runs completed*** is checked. Uncheck to restart with WET run no. 1 during next tomography processing.
- Jan 12, 2015 : set ***Iterations*** to 0 for any run number in above ***Edit WET Runs dialog***. Subsequent tomography processing of WET runs will end at first run number with ***Iterations == 0***.
- GeoTomCG software published by GeoTomo LLC now allows importing Rayfract® 2D tomograms recorded for parallel geophone lines and using this as a starting model for 3D tomography. Ask Daryl Tweeton for details at geotom@frontiernet.net .
- Hinojosa-Prieto and Hinzen use WET SRT and Poisson's ratio imaging at an archeological site.
- Pasquet et al. combine SRT with ERT and surface-wave dispersion to understand bedrock aquifer recharge.

Version 3.32 released in December 2014 :

- we now allow ***automatic WET inversion with layered starting model*** . The layered starting model is regenerated and you are prompted to start *WET inversion* whenever you run ***time-to-depth conversion in Depth menu*** with Plus-Minus, Wavefront or CMP intercept-time refraction methods.
- Dec 20, 2014 : default grid cell size in ***Smooth invert|Smooth inversion Settings*** again is determined as for version 3.26. Results in smaller default cell size than for version 3.31. Coverage plot looks better.
- Dec 9, 2014 : rename ***Window|Export depth section to .XYZ...*** to ***Window|Export depth section to .XYV...*** & export to ASCII .XYV to avoid file name conflict with *W_GeoSoft WinSism .XYZ* files.

- Dec 7, 2014 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Smooth nth iteration : n =*** is again set to 1 per default. This was set to 2 for version 3.31 and to 1 for earlier versions. Setting this parameter to 1 minimizes smearing artefacts e.g. at basement corner for SAGEEP11 synthetic data.
- Dec 7, 2014 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Smoothing filter weighting*** is again set to ***Uniform*** per default to avoid artefacts e.g. at basement corner of SAGEEP11. This parameter was ***Gaussian*** for version 3.31 and implicitly *Uniform* for earlier versions.
- Dec 4, 2014 : better prompt for *WET inversion* with *layered refraction starting model* just determined.
- Nov 28, 2014 : when opening a *profile database* with our Pro license we now check if *spread type* "999: 999 channels" is defined in the reference database. If not we automatically create this spread type.
- Nov 28, 2014 : when you change the *cell size* in *Smooth invert|Smooth inversion Settings* we now prompt you to confirm this. Once you have confirmed we delete starting models GRADIENT.GRD and DLTAGRAD.GRD in directory `\RAY32\<your profile name>\GRADTOMO`.
- Nov 28, 2014 : when you import shots or update the *recording geometry* we now also delete above starting models GRADIENT.GRD and DLTAGRAD.GR in `\RAY32\<your profile name>\GRADTOMO`.
- Nov 28, 2014 : ***XTV inversion flags in Smooth invert|Smooth inversion Settings*** are again unchecked per default. Unchecking these flags gives a more realistic starting model in case of *strongly undulating topography* e.g. for Line2 and often results in *deeper imaging with WET inversion* especially in case of velocity inversions below top-of-basement e.g. for Rjj9To10.
- Nov 24, 2014 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Automatically adapt shape of rectangular filter matrix*** is again enabled per default to avoid processing artefacts e.g. for Norcal14. See bullets below for hints on when to toggle this setting.
- Nov 24, 2014 : we now allow definition and use of *spread types* with up to 999 channels with our Pro license for ***import of shots with up to 999 channels***.
- Nov 24, 2014 : when importing a *.SPR spread file* which does not contain all spread types used in currently open profile we now show clear error message and disable processing of this profile until you import the correct *.SPR spread file*.
- Nov 21, 2014 : ***display a line with 330 m/s (air wave) slope*** starting at shot point in ***Trace|Shot gather*** :
  - right-click your mouse or touchpad with two fingers-on-pad gesture
  - move mouse cursor to change slope of line until it shows as 330 m/s in *status bar* at bottom of window
  - press F7/F8 to browse to next/previous shot to reset display of this unpicked polyline
- Nov 21, 2014 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Automatically adapt shape of rectangular filter matrix*** enabled for SAGEEP11 blind refraction data avoids the imaged basement "pulling up" at left section end where all wavepaths are aligned parallel to each other.
- Nov 20, 2014 : to ***display dialog titles in Windows 8.1 with smaller font*** select *Display* in *Windows Control Panel*, change size of *title bar font* to 8 or 9 points and click *Apply button*. This helps with *Header menu dialogs*.
- Nov 16, 2014 : define realistic *weathering velocity v0* determined in *Refractor|Shot breaks* by mapping traces to refractors with ALT+L. Now map traces to refractors in *Refractor|Midpoint breaks* as shown in Norcal14 tutorial on bottom of page 3 and run ***time-to-depth conversion using this shot v0***.
- Nov 15, 2014 : ***Window|Export depth section to .XYZ...*** export refractors to ASCII .XYZ with station number, station x/y coordinates, refractor elevations and velocities of current depth section.
- .XYZ format is same as .CSV format written by ***Window|Export ASCII Model of depth section...*** but writes two extra columns ***Station x***, ***Station y*** after ***offset*** column and before ***topo*** column.
- Nov 10, 2014 : updated documentation of *WET main parameters* in help file chapter *WET tomography processing*. Use updated winhelp.exe installer to ***update your installation with latest help file***.
- Nov 10, 2014 : ***WET Tomo|WET tomography Settings|More blanking during Conjugate Gradient inversion*** renamed to ***Alternate coverage update during Conjugate Gradient inversion***. Regarded when not using *Steepest Descent step* only. May result in more or less blanking at tomogram bottom.
- Nov 9, 2014 : *Grid|Plot refractors only without tomogram* and *Grid|Plot layer velocity without tomogram* flags are now disregarded when automatically plotting layered starting model after time-to-depth conversion in *Depth menu*.
- Nov 9, 2014 : when *Grid|Plot refractors only without tomogram* or *Grid|Plot layer velocity without tomogram* flag is checked we now ***plot refractor elevation or velocity in pink instead of white***. For older versions you can ***change the Base map Polyline color in Surfer Object Manager***.
- Nov 8, 2014 : *misfit prompt* recommends using ***overlapping receiver spreads with profile-internal far-offset shots*** for deeper and more reliable imaging and refers to http://rayfract.com/help/overlap.pdf .
- Nov 8, 2014 : when rays and wavepaths are aligned predominantly parallel to each other ***tomogram resolution is smeared at tomogram edges and start/end of non-overlapping receiver spreads***. See D.J. White 1989. For a good resolution wavepaths need to cross each other at angles of about 90 degrees.

- Nov 8, 2014 : far-offset shots are always used when determining the starting model. For 2D WET inversion ***far-offset shots are used if they are positioned inside overlapping spreads*** for which shots have been imported into the same profile database. See overlap.pdf for a good recording geometry.
- Nov 7, 2014 : improved Norcal14 tutorial instructions how to ***use edited weathering velocity during time-to-depth conversion***. See bottom of page 3 of 10 pages.
- Nov 4, 2014 : ***DeltatV inversion*** : fixed Ass. failure ***cmpCurve_.breaks_count > 0*** in CMPHELPR.CPP during static correction. For older versions press ALT+I to ignore this assertion.
- Oct 30, 2014 : ***WET Tomo|WET tomography Settings|Don't extrapolate grid rows*** does not extrapolate grid rows at left and right margins during WET. May prevent high-velocity artefacts below topography and at tomogram edges. May cause WET to fail especially in *Conjugate Gradient* mode. This option helps with lines Rjj9To10 and Norcal14 Fig. 12 & 15.
- Oct 27, 2014 : message boxes are now displayed with Windows style MS_APPLMODAL instead of previous style MS_SYSTEMMODAL. When working in a different application the Rayfract® icon in the task bar will flash once a message box is displayed. Click this icon to switch back to Rayfract®.
- Oct 27, 2014 : ***Smooth invert|WET with constant-velocity initial borehole model*** now uses constant-velocity starting model even if the deepest uphole shot is positioned above bottom of 1D-gradient starting model.
- Oct 18, 2014 : ***File|Import Data…|Select .HDR batch file dialog*** now resets the batch file selection to empty/none selected if you press ***Cancel button in selection dialog***.
- Oct 18, 2014 : ***Depth|Plus-Minus*** and ***Depth|Wavefront*** now reset the *.HDR batch fil*e selection to empty/none selected during import of extrapolated shots and restore the original .HDR selection. For older versions uncheck *Batch import*, click *Import shots* and click *End* to skip import of shots.
- Oct 13, 2014 : ***WET Tomo|Interactive WET tomograph|Edit velocity smoothing|Automatically adapt shape of rectangular filter matrix*** is ***unchecked per default*** for better vertical resolution. Enable for *half-height* of 0 or 1 rows to avoid artefacts. Also enable to better image dip of fault zones. This parameter is ***checked per default in version 3.26 and earlier*** resulting in ***more vertical smoothing***.
- Oct 13, 2014 : ***WET Tomo|Interactive WET tomography|Edit velocity smoothing|Automatically adapt shape of rectangular filter matrix*** should be enabled for steep topography e.g. TRA9002 using *minimal WET smoothing* with *filter half-height* 0 or 1 and disabled for horizontal topography e.g. LINE14 for increased vertical resolution. Enable for low-coverage lines with too few or noisy shots, to avoid over-fitting of first break picks during WET inversion. This parameter is ***unchecked per default since 3.31***.
- Oct 10, 2014 : ***updated help installer*** winhelp.exe now works under Microsoft Windows 8.1.
- Oct 2, 2014 : added links from new menu topics to screen shots and instructions in other chapters.
- Sep 29, 2014 : new help chapter ***Commands*** listing top-level menu commands with short descriptions. Install with updated winhelp.exe installer.
- Sep 28, 2014 : ***Depth conversion from model parameters dialog*** brought up with ALT+M in depth section window : call Surfer once depth section is redisplayed only.
- Sep 28, 2014 : ***Depth|Depth conversion Settings|No Extrapolation of shots*** does not generate extrapolated shots when there are gaps in traveltime coverage along the profile. Best leave unchecked.
- Sep 24, 2014 : fixed ***depth conversion after traveltime field regression*** with multiple sections, tested with NORCAL14 line and Wavefront & Plus-Minus methods.
- Sep 23, 2014 : export Plus-Minus results to .CSV at whole receiver stations only.
- Sep 21, 2014 : fixed 3-layer case interpreted with ***Plus-Minus method*** for NORCAL14 line.
- Sep 21, 2014 : improved conversion of .CSV layered depth section to layered .GRD starting model. We now interpolate refractor elevation and velocity at coverage gaps.
- Sep 20, 2014 : improved export of depth section to .CSV file in case of coverage gaps and multiple traveltime field sections per line.
- Sep 16, 2014 : improved SEG-2 import now regards ***trace descriptor block size*** when determining trace data start. This should make our SEG-2 import more robust.
- Sep 15, 2014 : improved ***detection of non-standard trace data start*** when importing SEG-2 files. We now allow the trace data to start either on double-word boundaries or directly after the SEG-2 trace descriptor block. Use ***File|SEG-2 import settings|Detect shifted trace data start with signal statistics*** if *Trace|Shot gather* does not show shot traces after SEG-2 import.
- Sep 14, 2014 : ***PASI ANTEO .SG2 SEG-2 import*** via ***File|Import Data…*** now per default assumes ***non-standard SEG-2 trace data start***. We tested this with 32-bit floating point sample files. For old SEG-2 import please check *File|SEG-2 import settings|Determine SEG-2 trace data start by User logic* and *Non-standard SEG-2 trace data start* before importing PASI ANTEO SEG-2 files.
- Sep 11, 2014 : ***Depth conversion|Export ASCII Model of depth section*** now exports each station only once and interpolates topography and weathering velocity when your line has coverage gaps and traveltime curves are combined into multiple sections.

- Aug 26, 2014 : if SEG-2 files do not specify the *distance unit*, our SEG-2 import now uses the default distance unit which you specify with ***File|Import Data Settings|Default distance unit is meter*** flag.

  For earlier versions check ***File|SEG-2 import settings|Get distance unit from user***. Otherwise our old SEG-2 import disregards source location and receiver location specified in the SEG-2 .DAT / .SG2 files in case of missing distance unit. This can happen with ABEM Terraloc Mark 6 files.
- Aug 26, 2014 : when you change ***Header|Profile|Profile Start Offset*** we now delete the starting models ..\GRADTOMO\DLTAGRAD.GRD & GRADIENT.GRD. This ensures correct regeneration of layered starting model during next time-to-depth conversion via *Depth menu*.
- for earlier versions of our software please delete files DLTAGRAD.GRD and GRADIENT.GRD in GRADTOMO directory and DELTATV.GRD in TOMO directory using Windows Explorer after changing *Profile Start Offset* to ensure correct regeneration of layered starting model.
- ***Depth|Plus-Minus***, ***Depth|Wavefront*** and ***Depth|CMP Intercept-Time Refraction*** now automatically export the layered depth section to .CSV, convert the .CSV to layered .GRD starting model, display this starting model in Surfer and prompt you to run ***WET inversion using this layered starting model***. Try this with our updated free trial and LINE14 sample profile : map traces to refractors interactively in *Refractor|Shot breaks*, then use *Depth|Plus-Minus* refraction method and subsequent *WET inversion*.
- ***Depth conversion|Automatically Export depth section to .CSV and .GRD*** is checked whenever you (re)open a profile database and enables above behaviour. The layered .CSV depth section and layered .GRD starting model are written to directory `C:\RAY32\<your profile directory>\LAYRTOMO`.
- ***Grid|Export grid file to ASCII .TXT*** now extrapolates x/y coordinates beyond first/last shot/receiver, for leftmost and rightmost grid columns. The previous version wrote leftmost and rightmost columns with the same x/y coordinates.
- ***WET Tomo|WET tomography Settings|Blank below envelope after last iteration*** unchecked helps to increase WET imaged depth, especially for a layered starting model.
- ***WET Tomo|Interactive WET tomography|Wavepath width [percent of one period]*** can be increased up to 100% to increase WET imaged depth.
- ***WET Tomo|Interactive WET tomography|Wavepath envelope width[% of period]*** can be increased up to 0.1% less than the *WET wavepath width* shown one field above, to increase the WET imaged depth.
- ***Smooth invert|Smooth inversion Settings|Allow XTV inversion for 1D initial model & Optimize XTV for layered starting model*** both unchecked can increase the depth of the 1D-gradient starting model.
- ***Smooth invert|Smooth inversion Settings|Limit WET velocity to maximum velocity in initial model*** unchecked can increase the WET imaged depth.
- to import Geometrics .BPK first break picks, use matching filenames for the SEG-2 .DAT or .SG2 and the .BPK files. For 2.DAT name the .BPK as 2.BPK in Windows Explorer. Then copy all .DAT or .SG2 and .BPK files into `\RAY32\<your profile name>\INPUT` and use our SEG-2 import routine via ***File|Import Data…*** .
- view our latest tutorial comparing using a 1D-gradient starting model vs. a layered CMP refraction starting model for WET inversion with Gaussian vs. Uniform smoothing with vs. without adaption of shape of rectangular smoothing filter.
- review our new tutorial showing *WET inversion* using a layered starting model.
- Zelt et al. 2013 compare refraction tomography software using synthetic data for a known fault model.
- Capizzi and Martorana use SRT, ERT, MASW and HVSR to image a landslide in 2D and 3D. SRT and ERT data inversion is constrained with stratigraphic information from continuous-core boreholes.

Version 3.31 released in July 2014 :

- ***Grid|Convert .CSV layer model to Surfer .GRD…*** lets you select a .CSV file with refractors exported from depth section (Fig. 17, last page) and then asks to select a Surfer .GRD tomogram created earlier. We replace velocities in the .GRD with velocities from the layered .CSV and use the same filename for the resulting layered .GRD as for your selected .CSV layered depth section. Use the layered .GRD as starting model for 2D *WET inversion*. Try this with our updated free trial and LINE14 sample profile : map traces to refractors interactively in *Refractor|Shot breaks*, then use *Plus-Minus refraction* method.
- ***Grid|Convert .CSV layer model to Surfer .GRD…*** interpolates refractor elevations and velocities between offsets listed in the .CSV depth section. You can ***extrapolate the basement refractor in the .CSV with a text editor*** e.g. Microsoft WordPad.
- *Smooth invert|Smooth inversion Settings|Extra-large cell size* further increases the cell size and speeds up WET inversion.

- ***Grid|Export grid file to ASCII .TXT...*** prompts to select a VELOITXY.GRD tomogram and converts the .GRD file to an ASCII .TXT file. Columns x/y/z/velocity are separated by a space ' ' character. This .TXT file can be imported into Golden Software Voxler.
- ***WET Tomo|Interactive WET tomography…|Conjugate Gradient*** does WET inversion with Conjugate Gradient method using Polak-Ribiere formula, with Secant method used for Line Search minimization. When you click this button, box *or RMS error does not improve for n* = is automatically checked.
- *WET Tomo|Interactive WET tomography…|Conjugate Gradient* checks *WET Tomo|WET tomography Settings|Limit WET velocity to maximum velocity in initial model* to prevent CG inversion artefacts.
- *WET Tomo|Interactive WET tomography…|Conjugate Gradient* inversion is made more robust by preventing invalid velocity updates to the tomogram.
- *WET Tomo|WET tomography Settings|Safe line search with bracketing and Brent* uses bracketing and Brent's method as in Numerical Recipes, Press et al. chapter 10 instead of Secant method for CG WET.
- *WET Tomo|Interactive WET tomography…|CG iterations* specifies number of Line Search minimizations done by Conjugate Gradient method, during WET inversion.
- *WET Tomo|Interactive WET tomography…|Line Search iters.* specifies number of WET iterations per Line Search minimization, during WET inversion with Conjugate Gradient method.
- *WET Tomo|Interactive WET tomography…|Tolerance* is the error tolerance Epsilon described by Shewchuk, for Conjugate Gradient method.
- *WET Tomo|Interactive WET tomography…|Line Search tol.* is the tolerance for Brent's method, used for Line Search minimization.
- *WET Tomo|Interactive WET tomography…|Initial step* is the initial guess for bracketing during Line Search minimization, before using Secant method or Brent's method for sectioning of the minimum.
- *WET Tomo|Interactive WET tomography…|Steepest Descent step* optionally updates the tomogram with a Steepest Descent step after each WET iteration, with starting model updated by Line Search method.
- *WET Tomo|WET tomography Settings|Hybrid Conjugate Gradient update formula* combines the Polak-Ribiere update formula with Fletcher-Reeeves to prevent CG "jamming". See Hager & Grant section 6.
- *WET Tomo|WET tomography Settings|More blanking during Conjugate Gradient inversion* does more blanking at tomogram bottom during CG WET inversion. Uncheck for deeper imaging when not using *Steepest Descent step* during CG WET.
- *WET Tomo|Interactive WET tomography|Edit grid file generation|Write grids for Line Search during Conjugate Gradient* stores the WET tomogram obtained after Line Search minimization by CG method.
- *WET Tomo* shows better error message in case of coverage gaps or invalid velocity grid. Increase CG *WET smoothing* or *wavepath width*, or use *WET Steepest Descent* method.
- *File|Import Data…* for SEGY .SGY files shows better error message with bad geometry in .SGY and recommends to select *File|SEGY import settings|No receiver coordinates specified in .SGY file* . For version 3.26 and earlier, you will see a message Ass. failed "SameDouble(ptr1->y,ptr2->y)" when station coordinates for same x and z coordinate differ in y coordinate.
- *File|SEGY import settings|No receiver coordinates specified in .SGY file* is now checked per default.
- *File|SEG-2 import settings|Detect shifted trace data start with signal statistics* detects byte offset of shifted sample data start by minimum variance of signal samples. Can fail with noisy traces.
- *File|SEG-2 import settings|First sample is at First non-zero byte* searches for first non-zero byte in trace data and assume this is the first sample. Fails when first sample starts with a zero byte. Test with setting *Non-standard trace start* checked.
- *File|SEG-2 import settings|Ignore SEG-2 trace descriptor block size* does not use trace descriptor block size specified by field X in *SEG-2 trace descriptor*, for determination of trace data start.
- *File|SEG-2 import settings|Non-standard SEG-2 trace data start* does not round up SEG-2 trace data start to next double-word (4-byte) boundary.
- *File|SEG-2 import settings|Skip 4 leading zero bytes at SEG-2 trace data start* skips 4 leading zero bytes at SEG-2 trace data start when reading the trace samples.
- *File|SEG-2 import settings|Standard SEG-2 string list termination* : per SEG-2 standard the end of the string list in the trace descriptor block is marked by two zero bytes. Uncheck to allow just one zero byte to mark end of string list.
- *Grid|Plot refractors on tomogram* now plots refractors in white instead of pink. You can change the refractor color in Surfer Object Manager. See our jenny13.pdf tutorial.
- *WET Tomo|Interactive WET tomography…|Edit velocity smoothing|Smooth last iteration* smooths the final WET tomogram after the last WET iteration.
- *WET Tomo|Interactive WET tomography…|Edit velocity smoothing|Smooth nth iteration* lets you specify how often WET smooths the tomogram during inversion. Increase for less smoothing.

- *WET Tomo|Interactive WET tomography…|Edit velocity smoothing|Smooth velocity update and tomogram after update* smooths both the velocity update and the tomogram, with update applied to it.
- *WET smoothing* per default uses ***Gaussian function for weighting*** of data in filter matrix, relative to central pixel to be smoothed. This makes WET inversion more robust and gives a better resolution than uniform weighting as used for earlier versions. You optionally still can use uniform weighting.
- *WET Tomo|Interactive WET tomography…|Edit velocity smoothing|Used width of Gaussian* lets you specify what weight is given to pixels on periphery of filter kernel, in sigma's of the Gaussian Bell function (range 0.1 to 6.0). Width of 0.1 sigma gives more weight to peripheral pixels than 6.0 sigma.
- *WET Tomo|Interactive WET tomography…|Ricker differentiation* is per default set to -1 for *Gaussian function* weighting of *wavepath velocity update*. This can improve lateral resolution of WET, e.g. to ***image basement faults or cavities in overburden***. Gaussian weighting helps most with increased *WET wavepath width*.
- *Gaussian weighting* also works better/more consistently than *Ricker wavelet weighting* (with differentiation set to 0) when varying the *WET wavepath frequency*, in *WET Tomo|Interactive WET tomography…* and gives more focused tomograms.
- *Smooth invert|Smooth inversion Settings|Extra-wide smoothing for 1D initial velocity profile* specifies a running-average *smoothing filter width* of 20% of the depth range of the *1D-gradient initial model.*
- *Smooth invert|Smooth inversion Settings|Decrease cell size* uses a smaller cell size when generating the Surfer .GRD formatted initial model grid. A smaller cell size results in a larger grid with more cells and can help to image layer boundaries with a sharper velocity contrast.
- *Smooth invert|Smooth inversion Settings|Extra-small cell size* uses an even smaller cell size when generating the Surfer .GRD formatted initial model grid. Available with our Pro license only.
- *Smooth invert|Smooth inversion Settings|Limit WET velocity to maximum velocity in initial model* can help to better resolve a sudden increase of velocity with depth at top-of-basement. Maximum depth imaged with *WET inversion* may decrease, with this option enabled.
- *Smooth invert|Smooth inversion Settings|Limit WET velocity to maximum velocity in initial model* is not regarded for constant-velocity initial model .GRD. See our COFFEY04 tutorial on page 2.
- *DeltatV|DeltatV Settings|Limit DeltatV velocity exported to maximum 1D-gradient velocity* is enabled per default for version 3.31. This option helps to ***suppress 1.5D DeltatV artefacts in the imaged basement***. With this new default option, DeltatV velocity in ZONDDATA tutorial is limited to 2,620 m/s in Fig. 1 similar to Fig. 3. Fig. 1 shows less basement artefacts than with version 3.26.
- *DeltatV|DeltatV Settings|Limit DeltatV velocity exported to maximum 1D-gradient velocity* determines the 1D-gradient starting model in a separate DeltatV run, before doing the *1.5D DeltatV inversion*. This 1D-gradient starting model is saved to disk as files ..\GRADTOMO\DLTAGRAD.GRD & .PAR .
- *DeltatV|Interactive DeltatV|Export Options|Max. velocity exported [m/s]* shows the maximum velocity in the 1D-gradient starting model file DLTAGRAD.GRD, with above new option enabled.
- *File|Import Data…|Import data type* shows new ***GeoTomo TimePicker .3DTT*** format option. Send us your *.3DTT test files* and we will make sure that we can import them.
- *Model|Model synthetic shots...* works again. This has been disabled since version 3.23. We apologize for any inconvenience caused. We thank our client roXplore gmbh for alerting us to this issue.
- *Model|Model synthetic shots…* now is enabled for our free trial and works with *irregular receiver spread types* e.g. for sample profile \RAY32\LINE14 .
- *Model|Model synthetic shots…* now resets synthetic picks to -1, and sets real picks to modeled times.
- *Window|Export ASCII Model of depth section…* now adds *Profile start offset[m]* to horizontal inline offsets from first profile receiver, in 2nd column of the exported *.CSV model file*.
- for versions 3.25 and 3.26, refractor plotting on tomogram works for English language setting only, as specified in ***Windows Control Panel|Region and Language settings***.
- to fix your Rayfract® 3.26 installation, run installer ray331_scripts.exe . This will install files from scripts.zip into your C:\RAY32\DAT directory. This does not work for version 3.25.
- *Grid|Plot refractors on tomogram* now uses a space character ' ' as column separator when writing the *.BLN file* with refractors to be plotted, in *AUTOTOMO.BAS script*. Version 3.26 uses a comma ',' .
- ***own number formatting instead of Print # formatting*** in AUTOTOMO.BAS, independent of current language setting and decimal mark (comma ',' or point '.'). So Surfer can always read the *.BLN file*.
- keep using ***Surfer 9*** when also installing *Surfer 12 free demo*. Select *Grid|Surfer invocation…* and *Scripter.EXE in C:\Program Files\Golden Software\Surfer Demo 12\Scripter subdirectory*. Start Surfer 9 via desktop icon. Run *Smooth inversion* and *DeltatV & WET imaging*, *Grid menu imaging* as usual.
- *Trace|Shot gather|ALT+P|Minimum time* can again be set to a value smaller than 0 e.g. -10ms, for clearer display and easier picking of traces recorded just besides the shot point.
- new *DeltatV & XTV flags* are appended at end of *GRADIENT.PAR & DELTATV.PAR files*. For early version 3.31 and earlier versions, these flags are written at end of *VELOITXY.PAR files* instead.

- *WET Tomo|Interactive WET tomography…|Start tomography processing* shows error message ***OpenPolicy : Access is denied*** under Windows 8.1 : restart Rayfract® 3.31 Pro via desktop icon, right-click icon and select 'Run as administrator'.
- *File|Open Profile...* shows error message ***Ass. failed spreadTypeObj.Okay()*** : click *Abort button*, select *File|Import Spread types...* and file MYSPREAD.SPR in your profile directory.
- we allow ***header data update in feet***, for *station coordinates* and *shot point coordinates*. See sample files `FEET.COR` and `FEETPTS.SHO` installed in your `\RAY32\DOC` directory. These files contain the word feet in the first header line.
- for help on our *.HDR batch import* see winhelp.exe topic *File formats* last section. We have added popup help topics for new *WET Tomo|Interactive WET tomography… controls* for Conjugate Gradient method. Use function key F1 to display popup help for control with current focus as usual.
- updated help chapters ***Introduction*** and ***WET tomography processing*** with latest ***Grid menu*** image and explanation of all Grid menu options and commands. Install with winhelp.exe.
- winhelp.exe help installer now works under ***Windows 8.1***, tested for Windows 8.1 64-bit Pro version.
- updated .pdf reference at http://rayfract.com/help/rayfract.pdf .
- SAGEEP11_13 tutorial shows how to improve resolution of *WET inversion* by systematically decreasing the *wavepath width*, using SAGEEP11 blind refraction data with known true model.
- our Expanded Abstract presented at SAGEEP 2014 in Boston, MA compares weighting of the WET velocity update with Gaussian function vs. Ricker wavelet weighting, using the SAGEEP11 blind refraction synthetic data with added noise. View our PowerPoint slides.
- view our updated brochure for all recently added functionality.
- Sloan et al. use SRT and MASW to detect shallow tunnels.
- Kotyrba and Schmidt show combination of seismic and resistivity tomography for the detection of abandoned mine workings, in EAGE NSG Early Online.
- Pérez et al. combine seismic refraction tomography with microtremor analysis and mechanical borings, for better geotechnical characterization of the subsurface.
- Ramboll uses SRT for offshore wind farm planning, with extensive marine streamer survey.
- Guerriero et al. use SRT and cone penetration testing for imaging of earth flows.

Version 3.26 released in December 2013 :

- *Trace|Shot gather* now offers *Processing|Stack shots…* to **add any *Source shot no.* to currently displayed *Target shot*, in profile database**. Check *box Subtract source* to subtract *Source shot* from *Target shot*. Test this with our updated free trial.
- we regard difference in *total delay time* (*shot delay* + *trigger delay*) between shots when stacking them, and allow for different *trace count* and *sample count* of shots, as long as the *sample interval* is identical.
- import the same *Target shot* with two different shot numbers, if you want to keep an unstacked version of the target shot in the profile database.
- *Trace|Shot point gather* now lets you **simultaneously pick traces recorded for any shot at current receiver station**, if new option *Processing|Pick all shots, in shot point gather* is checked. Use this option for shear-wave picking, with shots at same shot point but recorded with reversed trace polarity.
- trace samples are now stored in Rayfract® profile database as **32-bit floating point samples**, instead of 16-bit integer samples. This helps with higher-fidelity filtering and display of seismograph traces.
- ***before you open an existing profile database with version 3.26***, ***backup SEIS32.* profile database files to .RAR or .ZIP archive*** and external USB drive. Once you have opened a profile database containing seismograph traces with 3.26, you cannot open it with 3.25 or earlier any longer.
- *Smooth invert|Smooth inversion Settings|Extra-wide stack for 1D-gradient initial model* increases the *CMP stack width* up to 1200, for determination of the *1D-gradient starting model* GRADIENT.GRD .
- more robust .HDR batch import : allow ";" as column separator, without preceding " " space character.
- *File|ASCII column format...|Separator* has new value ":,;" without enclosing "". Use any of these 3 column separators (colon, comma, semicolon), for import of ASCII.ASC file with *File|Import Data…* .
- more robust *File|Import Data…* dialog, if you don't import any shots, either by using *Skip button* in *Import shot dialog*, or because of bad input files and/or specification errors in *.HDR batch import file*.
- improved import of **SARA s.r.l. DoReMi** seismograph generated SEG-2 files. We now support non-standard termination of SEG-2 string section with just one binary-zero byte, instead of two zero bytes.
- uncheck *File|SEG-2 import settings|Standard SEG-2 string list termination* for DoRemi SEG-2 files.
- *SEG-2 import setting|Get distance unit from user* overrides ***distance unit*** specified in SEG-2 file(s) during import, with your *Import Data Settings|Default distance unit is meter* setting.

- *File*|*Import Data…*|*Import data type Geometrics Plotrefa .VS* now regards *Take shot record number from* value *DOS file name*, but only if the current .VS file contains exactly one shot.
- *File*|*Import Data…*|*Import data type* SEG-2 now regards *Plotrefa .VS files* named as the *Geometrics .DAT files* (2.VS for 2.DAT). We read *shot position*, *layout start* and first break picks from this .VS.
- *File*|*Import Data…*|*Import data type* SEG-2 also regards *ABEM .FIR*, *Geometrics .BPK* and *Rimrock .PIK files* with *shot position*, *layout start* and first break picks, as in above bullet.
- *Layer .CSV file* generated in *Depth menu section* with *Window*|*Export ASCII Model of depth section...* now starts with header line with name of refraction method, unit feet or meters and profile name.
- *Grid*|*Reset DeltatV and WET settings to .PAR file...* now works with .GRD and .PAR pair generated for a different profile database than the one currently opened.
- *Grid*|*Plot refractors only without tomogram* and *Grid*|*Plot layer velocity without tomogram* now adapt the ***Surfer plot title***, with name of refraction method used, unit feet or meters, profile name and version. First regenerate the layer .CSV file as in above bullet, for this to work.
- *Grid*|*Plot refractors on tomogram* now converts values in *layer .CSV file* to feet when plotting refractors on .GRD file generated in feet or converted to feet. Regenerate layer .CSV as in above bullet.
- *Header*|*Station*|*Reset coordinates and v0 button* resets y to 0.0 for *Line type Borehole spread/line*.
- *DeltatV*|*Interactive DeltatV…*|*CMP curve stack width [CMPs]* has new max. limit of 1200, increased from previous max. limit 240. This helps with long marine/land streamer surveys, e.g. with *spread type separation string* 47*20 : 48 receivers, separated by 20 *station number intervals*. Use e.g. with spread-relative *receiver spacing* 2m and *Header*|*Profile*|*Station spacing* of 0.1m. This lets you specify *Layout start* and *Shot Pos.* in *station numbers* to an accuracy of 0.1m (max. error 0.05m), during data import.
- *Refractor*|*Midpoint breaks*|*Mapping*|*Automated updating of station V0* is unchecked during *Depth conversion* in *Depth menu*, if the *weathering velocity* is not specified at all stations. So when you next edit the weathering velocity in *Header*|*Station* and then remap traces to refractors, the edited velocity is preserved in *Header*|*Station*. *Automated updating of station V0* is checked during *profile (re)open*.
- *Refractor*|*Midpoint breaks*|*CLTR+F1* : ***zoom reduced time axis*** now flawlessly works at highest zoom levels, avoiding digitization "steps" in dip of zoomed *CMP traveltime curves*.
- *Refractor*|*Midpoint breaks*|*ALT+M* : ***mapping traces to refractors*** now works with *streamer spread type* as described in above bullet, with *receiver separation* of 20 *station number intervals*.
- *Refractor*|*Midpoint breaks*|*ALT+M CMP Stack Width* has new max. value of 1,200 CMP's vs. max. 240 CMP's for version 3.25 and earlier. This helps with streamer type surveys, see above bullet.
- *Refractor*|*Midpoint breaks*|*ALT+M Trace to refractor mapping parameters field* ***Refracted Wave Offset Delta*** has new default value of 5 *station spacings*, instead of former default 10, used for version 3.25 and earlier.
- *Refractor*|*Midpoint breaks*|*ALT+G Crossover distance smoothing* has increased max. *Overburden filter [station nos.]* and max. *Basement filter [station nos.]* of 2,000 station numbers.
- improved automatic update of *weathering velocity* in *Header*|*Station* after mapping of traces to refractors in *Refractor*|*Midpoint breaks*|*ALT+M*, if you skip *Crossover distance smoothing* (ALT+G).
- *Refractor*|*Midpoint breaks*|*Mapping*|*Update station V0 before depth conversion* speeds up layer-based refraction interpretation if you skip *Crossover distance smoothing* (ALT+G) after mapping (ALT+M).
- when skipping *Crossover distance smoothing*, increase *CMP curve stack width [CMPs]* instead in *refractor mapping dialog* (ALT+M), to suppress excessive oscillation of *crossover distance* along line.
- *Refractor*|*Midpoint breaks*|*Mapping*|*Update station V0 for crossover smoothing only* does not update *weathering velocity* in *Header*|*Station*, if you skip *Crossover smoothing* (ALT+G).
- *Depth*|*Plus-Minus…/Wavefront…/CMP Intercept-Time Refraction...*|*ALT+M* have increased max. *Overburden filter [station nos.]* and max. *Base filter width [station nos.]* of 2,000 station numbers. Use with long lines and land/marine streamer lines, see above.
- *WET inversion / forward modeling over grid* now always work after automated import of extrapolated shot branches with negative shot numbers, during time-to-depth conversion with *Depth*|*Wavefront* or *Depth*|*Plus-Minus*.
- *WET Tomo*|*Interactive WET tomography…*|*Edit velocity smoothing*|*Manual specification of smoothing filter* : if you set *Half smoothing filter height* to 1 and *Half smoothing filter width* to a small value e.g. 1, uncheck *Automatically adapt shape of rectangular filter matrix* to avoid WET artefacts.
- *WET Tomo*|*Enable AWE physical memory page caching* now automatically ***adds right SeLockMemoryPrivilege to current administrator account***, for Rayfract® 3.26 Pro license.
- for Rayfract® 3.25 or earlier Pro license, you need to add this right interactively as in ntrights.pdf .
- if under Windows 8.1 64-bit our Rayfract® Pro license shows error message "**Cannot enable the SE_LOCK_MEMORY_NAME privilege. Failed with error 1300.**", please reboot Windows 8.1, right-click Rayfract® desktop icon and select menu item *Run as administrator*.

- *File|External commands|Call Scripter and Surfer via batch* is always checked during profile (re)open.
- adapted AUTOTOMO.BAS script, now works again with Scripter version coming with Surfer 9.
- improved error handling and prompting when ***Golden Software Surfer call*** via Scripter fails.
- if Golden Software Surfer call via Scripter fails, please repair/reinstall Surfer 11.
- New short tutorial ZONDDATA shows 1.5D DeltatV and 2D WET inversion of synthetic traveltime data for known model. Also, we show CMP intercept-time layer-based refraction interpretation.
- Review Blind Test of Methods for Obtaining 2-D Near-Surface Seismic Velocity Models from First-Arrival Traveltimes (Colin Zelt et al., JEEG Sep 2013) .
- SAGEEP11_13 short tutorial shows optimized interpretation of SAGEEP11 blind refraction data.

Version 3.25 released in July 2013 :

- We now allow plotting overburden and basement refractors obtained with layer-based interpretation methods *Wavefront, Plus-Minus and CMP Intercept-Time Refraction* on WET 2D velocity tomograms.
- generate ASCII files WAVEMODL.CSV / PLUSMODL.CSV or CMPMODL.CSV with *File|Export header data|Export ASCII Model of depth section...* for depth section selected in *Depth menu* .
- *Grid|Select ASCII .CSV layer model for refractor plotting...* lets you select the ASCII model .CSV to be used for plotting of refractors with *Grid|Image and contour velocity and coverage grids…* .
- *Grid|Plot refractors on tomogram* plots refractors read from WAVEMODL.CSV / PLUSMODL.CSV or CMPMODL.CSV, on tomogram obtained with subsequent *WET inversion* and/or grid imaging. This helps to correlate layer-based interpretation with 2D WET inversion. Iteratively vary 1.5D layer interpretation including **mapping of traces to refractors** until it matches WET inversion output.
- *Grid|Image and contour velocity and coverage grids...* lets you reimage VELOITxy.GRD tomogram grid files using your latest *Grid menu option* settings, without having to rerun the WET inversion.
- VELOITxy. GRD files are in C:\RAY32\<your profile name>\GRADTOMO (*1D-Gradient starting model*) or …\TOMO (*pseudo-2D DeltatV*) or …\HOLETOMO (*Borehole line/spread*) directories.
- our Basic language script C:\RAY32\DAT\AUTOTOMO.BAS converts above ASCII .CSV to Surfer format .BLN files on the fly, when invoked via *Grid|Image and contour velocity and coverage grids…* .
- *Grid|Plot topography on tomogram* reads topography from above ASCII .CSV in AUTOTOMO.BAS .
- *Grid|Plot refractors only without tomogram* asks you to select a VELOITxy.GRD tomogram with *Grid|Image and contour velocity and coverage grids* but only uses this to determine limits and scale of the refractor elevation plot. Adapt limits and scale of the plot in Surfer as usual.
- *Grid|Plot layer velocity without tomogram* plots weathering and refractor velocities without tomogram.
- **edit *Style, Width, Color, Transparency, End Styles* of refractor polyline** in Golden Software Surfer's *Object Manager*. Click on *Base map icon* and the refractor polyline(s) now listed below it.
- **edit *Shape* of refractor polyline** by selecting it as in above bullet. Now select ***Edit|Reshape*** and select an individual node of the polyline with left mouse key. Hold down left mouse key and drag node.
- you need to **install Surfer 9 or later**, for above refractor plotting with polylines to work. Surfer 8 can only display one polyline or one refractor, per *Base map* and .BLN file.
- we now regard the current setting of *Page Units* in *Surfer Tools|Options|Drawing,* when plotting *DeltatV* and *WET inversion* output in Golden Software Surfer with Basic language scripts AUTOTOMO.BAS and DELTATV.BAS, located in directory \RAY32\DAT .
- *File|Export header data|Export Shot Point Coordinates…* now correctly exports absolute *shot point coordinates* shotX and shotZ for *Line type Borehole spread/line* .
- *WET Tomo|Interactive WET tomography...|or RMS error does not improve for n* = is now per default unchecked, when running *WET inversion* for a new profile or resetting parameters with *button Reset*, or when reopening an existing profile database with latest version 3.25 released in July 2013.
- *WET Tomo|Interactive WET tomography…* parameter *Wavepath width* can now be set to max. 500% instead of max. 100%, for more smoothing. This can help with deep imaging a few km below surface.
- *WET Tomo|WET tomography Settings|Scale wavepath width* and *Scale WET filter height* are now per default unchecked, for a short profile with 50 or fewer receiver stations.
- *Model|Model synthetic shots...* works again. This has been disabled since version 3.23 .
- improved robustness of traveltime field regression during *Wavefront* and *Plus-Minus* interpretation, in case of too low/too short refractor coverage with first break picks.
- tested with Microsoft Windows XP 32-bit, Windows 7 64-bit and Windows 8 64-bit, latest updates.
- check your first break picks for reciprocal traveltime errors in *Trace|Offset gather*. Repick single traces directly in *Trace|Offset gather* or in *Trace|Shot gather*. Or edit *Trigger delay* in *Header|Shot*, shifting all traces of one shot by a constant time shift. See geoexp13 Fig. 9 and riveral8 Fig. 11.

- to **pick shear-wave survey first breaks**, import two shots with same *shot position* (shot station no.) but reversed trace polarity generated by 'hitting the beam at the other end", and display traces for both shots in one display with *Trace*|*Shot point gather*. This makes picking much easier and more reliable.
- for modeling of **gradual increase of velocity with depth** in the starting model disable *XTV inversion* :
  - uncheck *Smooth invert*|*Smooth inversion Settings*|*Allow XTV inversion for 1D initial model*
  - uncheck *Smooth invert*|*Smooth inversion Settings*|*Optimize XTV for layered starting model*
  - select *Smooth invert*|*WET with 1D-gradient initial model* and confirm prompts as usual
  - disabling *XTV inversion* as above can give more reliable/deeper output with bad first break picks/too early picks
  - *XTV inversion* is enabled per default with above XTV flags for *Smooth inversion*, since 3.23
- to **speed up WET processing**, check *Smooth invert*|*Smooth inversion Settings*|*Increase grid cell size*, before selecting *Smooth invert*|*WET with 1D-gradient initial model*.
- Updated palmfig9 tutorial, now showing *Smooth inversion* and layer-based *Wavefront refraction*.
- for optimal interactive WET inversion of palmfig9 synthetic data, 9 shots into 49 receivers, increase *WET wavepath width* to 10%, run 100 *WET iterations*, disable *WET scaling of wavepath width* and *filter height*. Limit *Maximum valid velocity* to 3,000 m/s as guessed with *Wavefront refraction* method.
- to prevent Windows guest OS from freezing when run under Parallels Desktop and Mac OSX, increase *Computer sleep* and *Display sleep* to 1 hour or more, from default 15 minutes, in *Apple menu*|*System Preferences…*|*Energy Saver*. The Mac OSX screen saver will still kick in, after 15 minutes or so.
- New step tutorial shows how to build a synthetic "basement step" grid model with Surfer, and how to forward-model synthetic shots over this step.grd grid. We also show *Smooth inversion* and *Wavefront refraction* layer-based interpretation. We **plot the *1.5 D Wavefront refractor* on *2D WET tomograms***.
- New zivko13 tutorial showing *2D WET inversion* of reverse VSP survey, 49 shots from two boreholes into 24 receivers. Shoot from more than two boreholes to increase angular coverage and robustness of the 2D WET Wavepath Eikonal Traveltime tomographic inversion (Schuster 1993).
- Updated help file and help installer.
- Prof. Bob Whiteley compares published interpretations of SAGEEP 2011 blind refraction data with the true model, made available by Colin Zelt.
- Gasch Geophysical Services, Inc. shows determination of rippability (excavatability) characteristics of sub-surface materials, for box culvert construction .
- Dal Moro and Keller compares MASW with SRT and VSP.
- Schicht et al. show imaging of brine zones with SRT and ERT.
- View our contribution to thread http://forum.detectation.com/viewtopic.php?f=2&t=1817&start=50 .

Version 3.24 released in April 2013 :

- our parallel Eikonal solver now uses a separate memory pool for each thread during forward modeling of first break propagation. This prevents delays during parallel memory allocation from multiple threads.
- WET inversion now caches both shot and receiver traveltime grids. This speeds up the inversion with multiple threads running in parallel, minimizing delays due to single-threaded access to disk.
- improved robustness of support for Microsoft AWE Address Windowing Extension, when called from multiple threads during WET inversion with our Annual Pro Subscription license.
- we now write all *Smooth inversion and WET settings* to .PAR file, including recently added settings.
- restore inversion settings with *Grid*|*Reset DeltatV and WET settings to .PAR file...*
- toggling of *Smooth invert*|*Smooth inversion Settings*|*Increase grid cell size* resets *Initial velocity model* selection in *WET Tomo*|*Interactive WET tomography… dialog* to empty. This is required to prevent reuse of old/now invalid *WET wavepath width* and *WET smoothing filter size*, in interactive WET inversion. Reselect the starting model to redetermine wavepath width and smoothing filter size.
- *Trace*|*Shot gather* now allows **semi-automatic first break picking with polyline** for *Shot delay* and *Trigger delay* different from zero. Same for automatic first break picking with ALT+B.
- when you change the *Trigger delay* in *Header*|*Shot* we shift first breaks and polyline picked for this shot in *Trace*|*Shot gather*, by difference in *Trigger delay*.
- at high vertical zoom of time axis, the first break pick symbol (circle or cross bitmap) is not clipped any longer at bottom, in *Trace*|*Shot gather* display and other *Trace menu* displays.
- more accurate picking, round up/down mouse-picked time to the nearest sample in *Trace*|*Shot gather*.
- more accurate polyline picking, round interpolated pick time to the nearest sample in *Trace*|*Shot gather*.
- we now allow up to 100 nodes per polyline and shot gather, instead of only 20.

- added *buttons Filter|Cancel|Reset* to *Frequency filter dialog* ALT+Q, *Bandpass filter dialog* SHIFT+Q and *Trace processing dialog* ALT+M .
- Increase *DeltatV|Interactive DeltatV|CMP stack width* to e.g. 120 or 240 to minimize artefacts in case of strong refractor curvature, see tutorials ot0608, GEOEXP13 and broadepi.
- Test using *DeltatV|Interactive DeltatV|Static Corrections|Surface consistent corrections* instead of default *CMP Gather datum specific* in case of strong topography, see ot0608 and GEOEXP13.
- set *DeltatV|Interactive DeltatV|Static Corrections|Inverse CMP offset power* to 0.2 instead of default 0.5, to give more weight to traces for CMP at given offset from central CMP in stack.
- Updated tutorial lnec17.pdf showing Smooth inversion of borehole survey with 3 adjacent holes. Our *Smooth inversion* method assumes that all receivers are positioned in central borehole, and all sources are located in external (left and right) boreholes. If this is not the case, you need to sort traces by common receiver, for such a pair of two adjacent holes. See a13r1dm.pdf .
- if during *Smooth inversion* and *DeltatV inversion,* you see a prompt saying **Assertion failed! File: CMPPRCSR.CPP Expression: gradient_traceCount_ok** you can safely dismiss this with *Ignore button*. These prompts can sometimes occur when layer-stripping inversion of CMP sorted traveltime curves with *DeltatV method* encounters velocity inversions / low-velocity layers between higher-velocity layers. Such prompts should occur even less starting with version 3.24.
- Added web site page Synthetic modeling, listing links to tutorials and publications showing tomographic inversion of synthetic traveltime data generated for known models. Some of these tutorials come with ASCII formatted traveltime data. Objectively test accuracy of your own method with these data sets.
- tutorial GEOEXP13 shows reciprocity error check and how increasing WET wavepath width and envelope width results in deeper and more reliable imaging. See also our tutorial bulgatrl, showing systematic variation of WET wavepath width, to explore non-uniqueness of the solution space.
- Bavec et al. show imaging of a fault trace with ERT and SRT (Geological Survey of Slovenia 2012).
- Linn Karlsson shows determination of stratigraphic boundaries with SRT and push probe (Gothenburg University 2011).
- GEOVision Inc. shows imaging of shale bedrock with SRT and RQD (GEOVision 2010).

Version 3.23 released in December 2012 :

- **fast parallel WET inversion** uses up to 4 CPU cores both for forward modeling of traveltimes and back-projection of residuals over Fresnel volumes, using SIRT algorithm. CPU Usage up to 100%.
- Our Annual Pro Subscription license uses up to 8 CPU cores, for even faster WET inversion.
- tested under **Windows 8 Pro 64-bit**, with **Golden Software Surfer 11** free demo. Also tested under Windows 7 Pro 64-bit and Windows XP Pro SP3 32-bit.
- *Refractor|Shot breaks display* for long profiles e.g. GEOXMERC may hang/endless loop under Windows 8, at least with Parallels Desktop version 7 under Mac OSX 10.6.8 on iMac. Run Rayfract® under Windows 8 in **Windows 7 compatibility mode**, to avoid such graphics display driver issues.
- *Smooth invert|Smooth inversion Settings|Optimize XTV for layered starting model* configures XTV for strong velocity contrast between overburden and basement, in starting model for *Smooth inversion*. This new option is enabled per default, when creating a new or opening an existing profile database.
- *DeltatV|XTV parameters for constant-velocity layers...* has new buttons *Gradient model* and *Layer model*. Click these to reset XTV parameters for gradient model or layered model of subsurface velocity.
- tutorial jenny10 shows Smooth XTV inversion of synthetic data for layered model, and earlier output.
- *WET Tomo|Interactive WET tomography…\Ricker differentiation* can now be edited also for *Borehole spread/line* surveys. Set to a value of -1 for Gaussian weighting across wavepath.
- *File|SEGY import settings|No receiver coordinates specified in .SGY file* supports roll-along recording geometry. Specify *layout start* and *shot pos.* in .HDR batch file, for each shot to be imported.
- *File|Import Data…* now accepts .HDR batch files with empty trailing lines.
- Fixed sample .HDR batch file 2LAMB15.HDR , with corrected column *Shot Pos*.
- Fixed SEG-2 and SEGY import of 32-bit floating point samples with very low signal level, smaller than FLT_EPSILON. Such samples were not correctly scaled to 16-bit fixed point samples, during import.
- *File|Update header data|Update Shotpoint coordinates…* gives improved error message if *shot point x/y/z coordinates* in the .SHO file do not match the *shot station number* specified when importing the shot, see *Header|Shot* and *Header|Station*. In case of mismatch, backup your first breaks with *File|Export header data|Export First Breaks…* to BREAKS.LST . Then reimport the shot with corrected *shot station number*, optionally via .HDR batch import.
- *WET Tomo|WET tomography Settings|Disable wavepath scaling for short profile* is checked, when opening an existing profile or creating a new profile database with 24 or less receivers. For longer lines,

WET scaling is enabled. WET scaling of *filter height* and *wavepath width* improves resolution directly below topography, for consistent first break picks. For noisy picks or short lines, disable WET scaling, for more robust WET inversion.

- added *buttons Pick/Cancel/Reset* to *Automatic first break picking dialog,* ALT+B in *Trace|Shot gather.*
- *Smooth XTV* and *pseudo-2D XTV and DeltatV inversion* now re-read parameter records from the profile database when opening a different profile. This prevents reusing parameters from the previous profile.
- *WET Tomo|WET Velocity constraints…* lets you specify a velocity range, with two edit fields. All velocities outside this range are kept unchanged during WET inversion. This may be used for marine refraction surveys, with water overburden set to constant 1,500 m/s in the starting model.
- Fixed determination of *WET smoothing filter*. This was determined too small, for earlier 3.23 builds and line type *Borehole spread/line* .
- Build your own starting model in Surfer, see palmfig9 and thrust tutorials. E.g. add a constant-velocity water overburden to the initial model obtained with our Smooth XTV inversion or XTV inversion.
- Use blanking file SEIS32.BLN in directory C:\RAY32\<your profile name> for blanking above sea bottom, of GRADIENT.GRD or DELTATV.GRD. Copy this file to e.g. SEABOTTM.BLN and edit with Windows Notepad. Add lines to define varying sea bottom elevation along profile.
- Sometimes Surfer 8 has issues with recognizing .BLN end-of-file, with *Grid|Blank....* . Fix the .BLN with the free XVI32 Hex. Editor, ensuring that the .BLN file ends with exactly one pair of binary characters 0D, 0A meaning <cr><lf> at end of last non-empty line, and has no trailing empty lines.
- To generate the constant-velocity water overburden, use Surfer *Grid|Function…* . First open our GRADIENT.GRD or DELTATV.GRD initial model in Surfer, and select *Options|Grid Info…* to display grid limits and cell size. Reuse these values with *Grid|Function…* for your water overburden.
- Combine your constant-velocity water overburden with blanked GRADIENT.GRD or DELTATV.GRD to obtain your custom starting model with Surfer *Grid|Mosaic…* , see palmfig9 and thrust tutorials.
- Copy GRADIENT.PAR or DELTATV.PAR to match file name of your STARTING.GRD starting model, e.g. to STARTING.PAR .
- for a new installation, first download, backup to USB drive and run **base installer** http://rayfract.com/common/raywn323.exe . Next, download, backup to USB and run your customized **upgrade installer** named rayup323.exe. See our e-mail instructions.
- to update the green WibuKey or grey CodeMeter **dongle driver and runtime**, go to http://www.wibu.com/en/downloads-user-software.html . Select, download, backup to USB drive and run your runtime installer. There are two versions of CodeMeter runtime : Windows 32-bit vs. 64-bit.
- if you see a message saying “old runtime” or similar when starting up Rayfract®, you need to update the WibuKey or CodeMeter dongle driver and runtime, as described in previous bullet.
- if Rayfract® fails to start with message “CmDongle runtime system is not installed! “ or without any message, please add an exception to your firewall software e.g. McAfee or AVG, for CodeMeter.exe in path C:\Program Files (x86)\CodeMeter\Runtime\bin and/or reboot Windows.
- also add a firewall/anti-virus exception for executable file C:\RAY32\bin\Rayfract32.exe .
- when installing CodeMeter runtime 4.50 or higher in Windows 7 64-bit under Parallels Desktop running on Mac OSX, you may need to **add a port forwarding rule**. Otherwise time server access may fail. See http://rayfract.com/help/Parallels_Network_Config.pdf . Configure Network 1 of your Virtual Machine as “Shared Network”, both for fixed Ethernet cable and WiFi connection under Mac OSX. The Windows 7 Ethernet adapter is automatically rerouted over WiFi under Mac OSX.
- in rare situations, the Surfer® installation routine does not correctly update the Windows® registry, with path information. This may result in our Rayfract® software hanging, when invoking Scripter. If this happens, just uninstall and reinstall Surfer®.
- or select the Scripter .exe with *Grid|Surfer invocation…* , to avoid failure of lookup of Scripter path in Windows® registry, due to above Surfer® installation routine issues.
- improved lookup logic with Surfer® version 11 Demo, for Scripter path in Windows® registry.
- improved error message if Scripter path is not obtained with Windows® registry lookup.
- to use all installed RAM memory above 4 GBytes and up to 64 GBytes with Rayfract® Annual Pro Subscription & Permanent licenses with Windows® 64-bit Pro, configure Windows as in ntrights.pdf .
- Powers and Burton use SRT to investigate the depth to competent bedrock, at a construction site.

Version 3.22 released in August 2012 :

- use Gaussian function (standard normal distribution) for weighting of gradient update across wavepath (Fresnel volume). Set *WET Tomo|Interactive WET tomography…* field *Ricker differentiation* to -1 to

use **Gaussian weighting instead of Ricker wavelet weighting**. We scale one period (*wavepath width* 100%) to half-width of 3 sigma (3 standard deviations) of Gaussian bell function.

- Use above *Gaussian WET weighting* to avoid high-velocity artefact below shot point no. 3 for riveral8, with *WET wavepath width* of 100%. These artefacts can happen with *Ricker wavelet weighting*, if traveltime curves are picked too close to each other on the basement refractor and diverge towards the shot points. Alternatively, reimport such shots with corrected geometry and repick traces / correct picks with *Header|Shot|Trigger delay* if appropriate.
- *WET Tomo|Interactive WET tomography…*offers more **criteria for WET termination** : when RMS error goes below specified threshold in percent, or when RMS error does not improve for n iterations, or after x minutes of running the inversion.
- *WET wavepath width* and *WET smoothing* are now reset to defaults/redetermined whenever you toggle *Smooth invert|Smooth inversion Settings|Increase grid cell size*, or select *Smooth invert|Smooth inversion Settings|Reset Smooth Inversion settings*, or reset DeltatV settings.
- *Smooth invert|Smooth inversion Settings|Allow XTV inversion for 1D initial model* uses XTV inversion parameters configured in *DeltatV|XTV parameters for constant-velocity layers...* for determination of 1D initial model. Use this option in case of strong velocity contrast between overburden and basement.
- uncheck *DeltatV|DeltatV Settings|Reduced offset 0.0 is valid trace with time 0.0* for more shallow/realistic imaged depth of weathering layer, in case of sudden increase of velocity with depth. Otherwise leave this option checked, especially to avoid DeltatV artefacts due to bad picks.
- also uncheck *Smooth inversion|Smooth inversion Settings|Interpolate velocity for 1D-gradient initial model*, in case of low-velocity and thin overburden over high-velocity basement.
- for Surfer imaging of pseudo-2D XTV output, use **Natural Neighbor gridding method instead of default Kriging**, to avoid artefacts. Specify this in *DeltatV|Interactive DeltatV…|Export Options*. See tutorial jenny10, showing these Kriging artefacts, solely caused by Surfer gridding and imaging.
- for **pseudo-3D fence diagrams** we recommend Golden Software's Voxler software. This lets you import 2D WET tomograms which are formatted as Surfer .GRD files, as generated with our software. See sample http://rayfract.com/samples/9.bmp, made available by our client Terra Geosciences.
- new tutorial bulgatrl shows interactive varying of WET wavepath width, to explore non-uniqueness.
- as shown in bulgatrl, thrust12 and ot0608, increasing the *WET wavepath width* is a physically meaningful way of exploring the non-uniqueness of the solution space. For wide shot spacing and inconsistent first break picks **do not decrease the wavepath width from its default setting**, to avoid WET inversion artefacts / unstable inversion and over-fitting to noisy traveltime data with bad picks.
- increasing *WET wavepath width* to 50% or 100% can help to better image basement structure, with 100 WET iterations. Try this with LINE14 sample profile in \RAY32\LINE14, and with TRA9002 tutorial. This will not help with very shallow basement, just a few meters below topo, e.g. with thrust12 .
- interactively increasing the *WET wavepath width* has been possible since we first implemented WET inversion, about 12 years ago. We just for the first time show systematically in tutorial bulgatrl the effects of step-wise increasing of wavepath width, with *Degree of differentiation of Ricker wavelet* set to default value of 0.
- before 2008, default setting of *Degree of differentiation of Ricker wavelet* was 1, then was changed to 0 with version 3.05 released in January 2008. See below, in these release notes. With old default differentiation of 1 (Ricker wavelet once derived), increasing *WET wavepath width* can result in unstable inversion and "skeleton" artefacts (wavepaths engraving themselves into velocity tomogram). With new differentiation default of 0 (since version 3.05), increasing WET wavepath width works as intended, and results in smoother tomograms with less artefacts, as shown in our tutorial bulgatrl.
- Spetzler and Snieder state in The Fresnel volume and transmitted waves at end of abstract : "Last, we address the **misconception that the width of the Fresnel volume limits the resolution** in imaging experiments". See bulgatrl tutorial. Increasing width of wavepath (Fresnel volume) to 50% and even 100% (one wavelength) does not decrease resolution in basement, only just below the topography.
- tutorial thrust12 shows Smooth inversion of synthetic data for thrust fault model, with our free trial. This shows that Smooth inversion is capable of imaging strong lateral velocity variation, as long as shots are spaced closely enough and first break picks are accurate. If shots usable for 2D refraction tomography are too few (less than 7) and spaced too widely apart **then inversion will become highly non-unique**, as shown by Dr. Palmer in his SAGEEP12 presentation, and in our bulgatrl tutorial. **To reduce this non-uniqueness increase the WET wavepath width, shoot at every third receiver and pick first breaks consistently**, regarding the reciprocity principle. Use 24 receivers per spread instead of only 12, for more reliable imaging. For more information see our SAGEEP10 short course notes.
- Prof. Bob Whiteley comments on Mt. Bulga line 00 SAGEEP12 interpretation by Dr. Palmer.
- *Refractor|Shot breaks* **branch point picking** now positions the pick bar at discrete, valid positions between channels. This speeds up moving the pick bar to a new position, with left/right arrow keys.

- *Trace gather displays and Refractor|Midpoint breaks* now maintain own **independent cursor, for navigating of first breaks**. The *mouse cursor* is not repositioned to picked first breaks any longer. As a consequence, **windows can now be moved and resized** freely, within the main Rayfract® window.
- move the *Trace gather pick cursor* with *arrow keys* as previously. *Left/right arrows* reposition the cursor to previous/next trace. *Up/down arrow keys* move the cursor along the same trace. Hit *space bar* to pick the first break, at current cursor position. Alternatively pick with *left click of mouse*, at mouse cursor. This also repositions our own cursor.
- we now use bitmaps for first break picks : bigcross.bmp for modeled, redblack_circle.bmp (or optionally bigredcross.bmp, see next bullet) for picked first break, and hugeplus.bmp for pick cursor display. These .bmp files are in your \RAY32\RC directory. You may **replace these bitmap files with your own symbols**. Name the files as above. E.g. copy bluecircle.bmp to bigcross.bmp, copy redcircle.bmp to redblack_circle.bmp. Restart Rayfract®.
- *Trace|Processing|Use red cross for picked first breaks* shows picks with bitmap bigredcross.bmp .
- *Trace|Processing|Solid color pick display* displays pick bitmaps with AND operation instead of XOR.
- *Trace|Processing|Picks always cover traces* : picks are displayed in a separate loop, after all traces have been shown. Looks nicer for publication-quality output, but slower trace gather display when paging.
- Create your own bitmap .bmp files e.g. with free IrfanView utility. Create a new circular bitmap :
  - Image|Create new (empty) image
  - Leave Image width/height at 100 pixels, click Ok button
  - Edit|Show Paint dialog
  - Hover mouse cursor over Ellipse tool, read description
  - Left-click on Ellipse tool
  - Check Fill box at bottom of Paint dialog
  - Select color for interior/edge of circle, at bottom of Paint dialog
  - Press Shift key, move mouse cursor into white empty bitmap area
  - Keep Shift key pressed, press left mouse key at upper-left corner for circle bitmap
  - Still keep Shift key pressed, drag mouse to lower-right corner of circle
  - Release left mouse key and Shift key
  - Edit|Auto crop borders
  - File|Save as…, to C:\RAY32\RC\<your bitmap name>.bmp

- *Trace|Shot gather display|ALT+P* editing of **trace display parameters**, station number range and time window can now always be edited. When you change these limits, offset zooming (Shift+F1) and/or time zooming (F1) is disabled. *Processing menu items Edit…* will be checked automatically. Uncheck item *Edit offset range*, to restore offset zooming. Uncheck *Edit time window*, to restore time zooming.
- adapted to work with **Golden Software Surfer® version 11**, tested demo version. Test our free trial.
- if you specified **page units centimeters** in Surfer *Tools|Options|Drawing*, we now reset this internally to inches, for consistent display of DeltatV and WET tomograms.
- *Depth menu depth sections* show axis labels with two digits after decimal point, if depth range < 1.0m.
- support import of SEGY files written with **Seismic Unix, ProMax** and **SPW**.
- support importing **SARA s.r.l. DoReMi** seismograph generated SEGY and SEG-2 files.
- support import of SEGY files generated with **Seismic Source** and **Lakkolit X-M3** seismographs.
- **support non-standard SEGY .SGY import**, with *File|Import Data…* .Test this with updated free trial RAYTRIAL.EXE . This now allows import of **Ambrogeo Echo 12/24** non-standard .SGY files. Enable the following three new SEGY settings for this to work :
- *File|SEGY import settings|Non-standard byte ordering : low byte stored first (NOT big-endian)* allows import of .SGY disk files with words stored in reversed byte order (little-endian).
- *File|SEGY import settings|One shot per .SGY file : disregard original field record number in trace header* assumes that all traces in one .SGY file belong to one shot record, when importing.
- *File|SEGY import settings|No receiver coordinates specified in .SGY file* assumes that .SGY does not contain valid receiver coordinates. Our SEGY import routine determines *receiver position* for each .SGY channel via *channel number, Default spread type* and edited *layout start*.
- *File\SEGY import settings|Set SEGY settings for Ambrogeo Echo non-standard .SGY file* will preset above three settings.
- if input file(s) imported with *File|Import Data…* do not end with a *shot number*, the shot number is now determined from header values specified within such files.
- in *Header|Station*, *Correct breaks button* is now enabled always, not only when copying weathering velocity with buttons *v0 from CMP* or *v0 from Shots*. **Interactively edit and interpolate v0** in *Header|Station*, and then correct for shot position offsets with *Correct breaks button*. Next enable *Copy v0 from Station editor* in *DeltatV|Interactive Delta-t-V|Static Corrections*, and redo DeltatV inversion.

- Bedrosian et al. use SRT, ERT, TEM, MT and LiDAR to image structure beneath an earthen dam.
- Ruiz-Villanueva et al. use SRT, Time Domain Reflectometry (TDR) and geotechnical tests for hydrogeomorphic characterization of a shallow landslide.
- Burton et al. use SRT, ERT and borehole logs to investigate preferential flow paths for contaminants.
- Travelletti et al. use SRT and laser scanning to define the geometry, the kinematics and the failure mechanism of a large landslide.
- Gazdek et al. use SRT to image soil improvement by embedding of gravel cylinder columns (piles).

Version 3.21 released in April 2012 :

- **SEGY .SGY import**, in *File|Import Data*….Test this with updated free trial RAYTRIAL.EXE .
- support importing multiple shots stored in same SEGY .SGY file.
- display of SEGY trace header fields *FieldRecordNo* and *EnergySourcePointNo* in *Header|Shot* .
- *Shot pos.* and *Layout start* are determined by dividing .SGY *source/group x/y/z coords.* by *Station spacing* as specified in *Header|Profile*. You can edit these station numbers in *Import Shot dialog*.
- check *File|Import Data Settings\ Keep same Layout start for consecutive shot files* and *File|Import Data Settings|Default layout start is 1.0* to assign station number 1 to leftmost profile/spread receiver during following import, with *File|Import Data…* . This works again for SEG-2 import as well.
- **Batch import of shot files**. You can *specify shot file name, sequential shot number in input file, shot number in database, layout start, shot pos.* etc. in a .HDR import batch file. Tested SEG-2 and SEGY import, with one or multiple shots per SEG-Y file. See 2lamb15.hdr for a sample .hdr batch import file, specifying import of shots from two .sgy files.
- Updated mdw2011.zip with mdw2011.hdr batch file, for tutorial mdw2011.pdf .
- *WET Tomo|Coverage plot setup…* allows thinning of the WET coverage plot. Specify *every nth shot and receiver* for which wavepaths are plotted. **Easier visualizing of wavepaths**, with dense plots.
- *WET Tomo|WET tomography Settings|Export modeled WET times to .LST* writes VELOITXY.LST files with picked and modeled times, for tomogram VELOITXY.GRD and during WET inversion.
- *Model|Forward model traveltimes...* now forward models first break times with our *Eikonal solver* for both sources and receivers, and determines an improved synthetic time by taking the average of forward time (from source) and reverse time (from receiver), for the same ray and trace.
- wider *station number range*, now from -1,000,000 to 1,000,000. Previously was -10,000 to 10,000 .
- improved Wavefront and Plus-Minus refraction methods for long sections. We allow larger values for ***smoothing parameters*** (*overburden filter*, *basement filter*). See our updated tutorials ot0608.pdf and GEOXMERC.pdf .
- wider text fields showing selected .GRD and .PAR files of selected initial model, in *WET Tomo|Interactive WET tomography…* .
- write new *Smooth inversion* and WET settings to .PAR files.
- *Grid|Reset DeltatV and WET settings to .PAR file…* **restores inversion parameter settings from .PAR** file, associated with selected DeltatV, Gradient or WET velocity .GRD file
- improved robustness of memory management during *DeltatV* method inversion, for large data sets.
- *Trace|…gather|Processing|Edit offset range* allows editing of station number range with ALT+P, used for displaying trace gathers with *Trace menu*. This disables horizontal zooming with SHIFT+F1.
- *Trace|…gather|Processing|Edit time window* allows editing of time window with ALT+P, used for displaying trace gathers with *Trace menu*. This disables vertical time zooming with F1.
- *GeoTomCG .3DD* and *Geometrics Plotrefa .VS* import routine sequentially increases shot number when importing multiple .3DD or .VS files, stored in same *input directory*. Previously, the shot number was reset to 1 for first shot of each file.
- more accurate determination of *shot position*, during import of shots, editing in *Header|Shot* , updating *shot points* with SHOTPTS.SHO and when forward modeling traveltimes with Eikonal solver. Helps with strong topography and lateral offsets. Now stores 3 digits after decimal point instead of 2 digits.
- *Smooth inversion Settings|Increase grid cell size* now gives .GRD Surfer grids with at least 400 columns, instead of at least 600 columns, and at least 100 rows. This further increases cell size.
- *Smooth invert|Smooth inversion Settings|Wide smoothing filter for 1D initial velocity profile* sets vertical smoothing filter width to 20% of depth range of *1D-gradient initial model*, instead of 10%.
- increased minimum required *WET wavepath width* in *WET Tomo|Interactive WET tomography…*, to 20% of unscaled default value, to prevent the publication of artefacts. Too narrow wavepath width and *Fresnel volume width* is physically impossible and meaningless. See Fig. 1 in Hagedoorn 1959.
- See SAGEEP10.pdf for help on *WET wavepath width* and other WET and DeltatV settings.

- fixed scaling bug in *Refractor|Midpoint breaks display*, for long seismic traces (riveral8.pdf).
- fixed a few corner cases when mapping traces to refractors in *Refractor|Midpoint breaks display*.
- allow importing non-standard **Micromed SoilSpy Rosina SEG-2 files**.
- allow import of non-standard **DMT SUMMIT SEG-2** trace files.
- *File|SEG-2 import settings submenu*, for more control over **determination of SEG-2 trace data start**.
- recommend to improve first break picks if *normalized RMS error* larger than 3%. Refer to riveral8.pdf .
- Updated Windows Help file rayfract.hlp . Install via rayhlpup.exe installer. Updated topic **Crosshole survey interpretation**, and new topic **Downhole VSP interpretation**.
- to open **Windows help files under Windows 7**, you need to download and install Microsoft WinHlp32.exe . This component is not included out-of-the-box any longer.
- Regenerated rayfract.pdf from latest version of help file, now with graphics.
- Updated function_keys.pdf , listing new keyboard shortcuts ALT+Z and SHIFT+Z.
- Ot0608.pdf tutorial shows interpretation of a large and dense data set, with Smooth inversion, XTV inversion and Wavefront refraction. These methods show good agreement with each other.
- Updated tutorial clud1.pdf . Uncheck *WET tomography Settings|Disable wavepath scaling for short profile*, to get more resolution directly below topography. Weathering layer looks more realistic.
- set *WET Tomo|Interactive WET tomography… |Degree of differentiation of Ricker wavelet* to 1, to obtain sharper/less smooth WET output, e.g. for SAGEEP11 refraction data set. Watch for artefacts.
- Benjumea et al. 2011 compare ERT with SRT (WET tomography) and Nakamura H/V method.
- Lamb et al. 2011 show geothermal fault imaging with ERT, SRT and SP, on an AGU 2011 poster.
- Doug Crice describes how to record and process borehole shear-wave surveys including VSP
- pick S-wave first breaks in our *Trace|Shotpoint gather* display, for pairs of shots with reversed trace polarity, recorded at common shot points.
- Use Matlab code fn_writeseg2.m to convert SEGY files to SEG-2. We provide this code as is without support, and you need to adapt it to your situation (number of channels, number of samples per trace). Also, you need to load the SegyMAT module, on which this code depends. We thank Andrew Lamb at Boise State University for making this code available.
- install and run Rayfract® under **Parallels Desktop on an Apple iMac or MacBook Air portable**, e.g. in a Windows 7 virtual machine. We tested Parallels 6 with Mac OS X 10.6 Snow Leopard on iMac, and Parallels 7 with Mac OS X 10.7 Lion on MacBook Air. Adapt the Apple keyboard mapping :
  - in Apple menu under Mac OS X, select System Preferences… and Keyboard. Check **Use all F1, F2, etc. keys as standard function keys**, for easy usage of **function keys in Windows**.
  - map Windows style right-click to Ctrl+Click, in Parallels Desktop|Preferences…|Keyboard.
  - disable Mac OS X system shortcuts in Parallels Desktop|Preferences…|Keyboard.

Version 3.20 released in October 2011 :

- *WET Tomo|WET tomography Settings|Enable AWE physical memory page caching* uses RAM memory above 4GB, up to 64 GB, for traveltime grid caching during WET inversion, with Microsoft® Address Windowing Extension. Also see Mark Russinovich's description of AWE. This setting is enabled with our **Rayfract® Pro annual subscription license** only. Ask for our pricing. Normally 32-bit Windows® applications can only use maximally 2 or 3 GB of RAM. This option speeds up WET inversion by up to 5 times for large data sets, by avoiding disk access and virtual memory paging/swapping to disk. We recommend running our Annual Pro license under Windows 7 64-bit.
- **more WET regularization/smoothing, for low-velocity sections**. Based on average velocity of the initial model, we now automatically increase default *WET wavepath width* and *smoothing filter size*, for low-velocity sections e.g. shear-wave surveys or areas with thick non-consolidated, loose overburden.
- *Processing|Frequency filter…* allows **frequency filtering with single-pole filter or Chebyshev-Butterworth**, in *Trace|Shot gather display*. High-pass or low-pass filter. Edit *cutoff frequency*, and *number of times* the filter is cascaded. Edit *percent ripple* and *number of poles* (relevant for Chebyshev-Butterworth only).
- each filter stage is in turn convolved with the (filtered) trace signal, for better numerical stability.
- we optionally do **bidirectional filtering**. This can help to better preserve the wave form of the recorded signal and first break pulse.
- *Processing|Bandpass filter…*shows ***Band-pass/Band-reject dialog***, in *Trace|Shot gather*. Uses single-pole filter or Chebyshev-Butterworth twice, in sequence for band-pass and in parallel for band-reject.

- per default, we use single-pole filter, for above high-pass/low-pass and band-pass/band-reject filters, instead of Chebyshev-Butterworth. This reduces overshoot and ringing in trace display, but has more gradual roll-off in frequency domain.
- For more information on these digital filters, see http://www.dspguide.com/ , chapters 19 and 20.
- four most recent profile databases are listed at bottom of *File menu*. Select any of these to quickly reopen the database, containing trace data, header data, recording geometry and inversion parameters.
- when you reopen any profile database, trace gather displays shown with *menu Trace* are restored to same settings (coloring, zooming, filtering, processing) as when you worked with these the last time.
- trace processing and display settings in *menu Processing* are stored separately for each trace gather type, as selected with *Trace menu*. These settings are also restored, when you reopen a profile database.
- *Velocity display|Show maximum velocity at bottom* option. Plot velocity graph with inverted velocity axis, with velocity increasing towards bottom. Better correlation with depth section display.
- *Smooth invert|Smooth inversion Settings|Increase grid cell size* increases default cell size for the initial model grid. This allows longer initial models, regarding constant maximum grid node count of 640,000. Use to avoid **Degenerated grid message**, for **long, shallow initial models and marine surveys**. For both short and long profiles, grid row count decreases, to at least 100 grid rows instead of at least 200 rows. This speeds up *WET inversion*. With this option enabled, *WET inversion* may become instable, in case of velocity inversion. WET *RMS error* will slightly increase.
- our Rayfract® Pro annual subscription license allows larger grids with up to 1,280,000 nodes.
- *WET Tomo|WET tomography Settings|Disable traveltime grid caching* results in all *traveltime grids* being written to disk, instead of cached in RAM. May reduce disk swapping, in case of low RAM.
- *File|Update header data menu* items *Update First Breaks…* , *Update from Gremix .GRM files …* and *Update from OYO .ODT files…* don't reset the trigger delay of updated shots any longer.
- our *Interpex Gremix .GRM import routine* now accepts a *station interval* (specified on first line of .GRM file) smaller than 1.0. Previously, the *station spacing* was reset to 1.0m in this case.
- fixed determination of *source/receiver elevation* during SEG-2 import into *borehole spread/line*, based on *Station spacing*, *Default spread type*, *Layout start* and *Shot pos*. specified during import.
- fixed first break picking in *Trace|Shot gather* if *Refractor|Shot breaks* is open. This was broken in early version of 3.20. Just close *Refractor|Shot breaks window*, so picking in shot gather works fine again.
- we do not support running our software under Microsoft® Windows 2000 any longer. When starting version 3.20 under Windows 2000, it recommends using Windows XP, and shuts down again.
- if Rayfract® can't open a profile database under Windows 7 64-bit, shutting down with an error message instead, right-click the Rayfract® *desktop icon* and select *Run as administrator*. Retry open.
- before backing up a profile database (files SEIS32.*), always first exit via *File|Exit*, to close the database. Otherwise the profile database is still opened and being updated by Rayfract®. **Backing up an opened database results in missing database files, or in a corrupted snapshot of the database**.
- if you change Surfer *Preferences|Drawing|Page Units* to *Centimeters* from default *Inches*, tomograms plotted with Rayfract® will be too small. Just revert this Surfer setting to Inches, to fix this issue.
- to update your rayfract.hlp help file and Rayfract® help menu, download our new installer http://rayfract.com/help/rayhlpup.exe and run on the PC holding your current Rayfract® installation.
- updated thrust tutorial, showing building of a thrust zone model grid with Golden Software Surfer. Now shows easier forward modeling of dummy shots over this grid, to obtain synthetic shots. Following *Smooth inversion* shows that our WET inversion is capable of **imaging lateral velocity variation**.
- Tutorial riveral8.pdf shows WET inversion of 6 shots into 12 receivers, imaging a sapprolite setting. Also, we show our new band-pass frequency filtering, and how to **quality-check first breaks and picks in *Trace|Offset gather*, according to traveltime reciprocity principle**.
- Tutorial mdw2011.pdf shows SEG-2 borehole shot import, header data update and Smooth inversion.
- tutorial lnec17.pdf shows how to image two adjacent cross-hole surveys (3 boreholes) in one tomogram. You can import SEG-2 shots into *borehole spread* profiles instead of .3DD shots. Just select the *import data type* in our *Import shots dialog*. See above mdw2011.pdf .
- updated tutorial camp1 shows how to build a custom layer-based initial model and use this for WET inversion. We recommend to always use our default 1D initial model, with Smooth inversion method.
- for surveys with homogeneous overburden, including marine streamer surveys, pseudo-2D DeltatV can work well, even without running WET inversion. See GEOXMERC.pdf and ot0608.pdf . The longer the overlapping receiver spreads and the resulting seismic line, recorded with roll-along technique customary in reflection seismics, and the denser the receiver and shot spacing, the better DeltatV will work. DeltatV and XTV parameters need to be tuned; see above two .pdf tutorials.
- Falgàs et al. show mapping of a deltaic subsurface system near Barcelona, with audiomagnetotellurics, reflection and refraction seismics interpretation (WET tomography), combined with borehole logs.

- Boiero and Socco compare surface wave analysis with WET tomography, using both synthetic model-generated and field-recorded data. These two methods show good agreement with each other.
- Benjumea et al. 2008 show combining seismic and CSAMT methods in a sinkhole site study.
- Robert Whiteley comments on Mt. Bulga refraction data interpretation published by Dr. Palmer. Regarding Dr. Palmer's response, our WET inversion is capable of **imaging lateral velocity variation**, see our thrust.pdf tutorial and tutorials epikinv.pdf, broadepi.pdf, fig9inv.pdf and SAGEEP11.pdf, showing inversion of synthetic data generated from known models. These tutorials come with links to the synthetic data and model files. So anybody can verify our imaging, or test their own inversion method. We continue to recommend running at least 50 or 100 WET iterations. This enables our WET inversion to **remove artefacts of the initial model**. This removal of artefacts is shown in our tutorials thrust.pdf, epikinv.pdf, broadepi.pdf, fig9inv.pdf and SAGEEP11.pdf .
- Thesis Stefan Jansen, Niels Bohr Institute, University of Copenhagen 2010 evaluates WET with synthetic data for models of faults and small velocity anomalies, in Appendix C. Using 50 WET iterations as recommended, helped to **remove horizontal layering artefacts of the 1D initial model**.
- For theoretical determination of resolution limit of WET inversion see Sheng and Schuster 2003.

Version 3.19 released in June 2011 :

- **select and configure Printer in *File*|*Print Setup*…** under Microsoft Windows® Vista and Windows 7. Once done, click on *Print button*, then select *File*|*Print* to print the currently selected window. For version 3.18, left-click *Windows 7 Start button* and select default printer in *Devices and Printers*.
- *Window*|*Display annotations in Arial* uses Arial font, for axis annotation. Uncheck for Sans Serif font.
- *Window*|*Large annotations* uses large font, for display of axis title and labels. Uncheck for small font.
- *Window*|*Print wide sections with large annotations* for **report-style .PDF graphics, when printing to Adobe Acrobat or CutePDF Writer**. Specify horizontal scale and vertical scale with ALT+P in corresponding section window. Uncheck this when printing high sections, to prevent too large font.
- *Window*|*Print with display colors* uses orange color for printing of traveltime curve segments mapped to weathering layer (refractor 0), in *Refractor*|*Shot breaks* or *Refractor*|*Midpoint breaks* . Uncheck this to print with light blue color instead.
- **delete all first break picks for current shot** in *Trace*|*Shot gather*, with SHIFT+Z keyboard shortcut.
- **delete all branch points for current shot** in *Refractor*|*Shot breaks*, with SHIFT+Z keyboard shortcut.
- easier shortcuts for deleting branch points in *Refractor*|*Shot breaks*, now with ALT+F1, ALT+F2 .
- new ALT+Z shortcut for deleting first break pick of current trace, in *Trace menu gather displays* .
- always draw traveltime curves with solid pen in *Refractor*|*Shot breaks* for *Line type Borehole spread/line*, independent of *Station spacing* and actual *receiver spacing.*
- improved **AGC Automatic Gain Control** in *Trace*|*Shot gather*, ALT+M. *AGC window length* can vary between 0 and length of trace. All samples at trace start/end are gained, independent of window length.
- *Smooth inversion* and *WET processing* now are enabled once you **import at least 3 shots into your profile database**, for *line type Refraction spread/line*. Also, these methods refuse to run if your *shot spacing* is too wide, compared to the *receiver spacing*.
- *Smooth invert*|*Smooth inversion Settings*|*Extrapolate tomogram over five station spacings* lets you use shotpoints offset maximally 5 station intervals from first/last profile receiver, for *DeltatV* and *WET* . May cause velocity artefacts in tomogram, due to missing receivers. Use if absolutely necessary only.
- fixed endless loop in *Wavefront method* for short profiles, if forward/reverse refractor segments do not overlap sufficiently, with *Depth*|*Depth conversion Settings*|*Link traveltime curves* checked.
- faster back-projection of residuals along wavepaths, with SIRT-like algorithm, during WET inversion. **Up to 25% faster overall WET inversion**, for large and dense data sets. Small data sets 5% faster.
- database utilities for creating a new profile, checking a profile database, importing and exporting spread types, and Scripter are now called directly instead of via .BAT batch file. This should help to avoid **issues with too stringent security checks for .BAT files**, e.g. under Windows XP SP3.
- improved error handling logic when calling external commands such as database utilities. Easier to understand error messages. For DBREV.EXE database revision utility, exit codes are translated to text.
- when running 3.19 under Windows Vista, select *File*|*Call batch via PIF file*, before running our *Smooth inversion* etc. Otherwise Rayfract® cannot call into Golden Software Scripter and Surfer version 8.
- if **Golden Software Scripter utility hangs and/or shows ActiveX errors**, please upgrade to Surfer version 10. The free demo version is available at http://goldensoftware.com . First startup Surfer via *desktop icon* and click on *Splash screen*, to avoid delay or Scripter errors. Next image tomograms with Rayfract® using *Smooth invert*, *WET Tomo* and *Grid menus*, as usual. If Scripter still hangs, right-click

Surfer desktop icon and select *Run as administrator*. Surfer 10 also offers corrected **Grid blanking** with *Grid|Blank...* , for large .GRD grid files.

- you can have multiple Surfer versions installed at the same time. Just start the desired version with its *desktop icon*, before running Rayfract®.
- updated rayfract.hlp help. Run raywn318.exe to install this. With more information, easier instructions and lots of screen shots of dialogs and menus.
- Updated uphole tutorial coffey04.pdf . We reprocessed this with version 3.19, and updated instructions.
- to suppress horizontal layering artefacts in the 1D initial model, **limit the maximum exported DeltaV velocity to e.g. 3,000 m/s instead of default 5,000 m/s**. See palmfig3.pdf and SAGEEP10.pdf, page 25 of 44. This will speed up convergence, together with increased *WET iteration count* of e.g. 200.
- for high-quality seismograph traces with good signal-to-noise ratio, we recommend to **stack 10 or 12 shots at the same shot point. This enables accurate first-break picking**, a prerequisite for SRT .
- For exact shot timing try GISCO piezoelectric trigger switches . Timing is essential for shot stacking.
- try **disabling AGC on your seismograph when stacking shots**. Otherwise pre-first break noise may not cancel out while adding shots to the stack. Verify this on your seismograph trace display.
- aim for an **RMS error below 2%** (as shown on top of WET tomograms). For higher RMS errors, check and fix first break picks, in *Trace gather* and *Refractor|Shot breaks* displays. See GEOXMERC.pdf .
- for noisy traces, uncertain first break picks and *Smooth inversion RMS error* above 2%, **increase the *WET wavepath width*,** e.g. multiply by two. This gives smoother WET output, avoiding artefacts.
- also increase *WET wavepath width* if subsurface velocity is slower than normal, e.g. in case of S-wave surveys and low-velocity, unconsolidated overburden sediments. Otherwise the too thin wavepaths may cause **black uncovered regions in the *wavepath coverage plot***, with too wide shot spacing. This may prevent a robust convergence towards meaningful interpretation, with increasing *WET iteration count*.
- SRT Seismic Refraction Tomography and seismic refraction methods in general will not work reliably or at all in **strong velocity-inversion situations**, with a high-velocity layer (paved road) above a lower-velocity sediment layer. You may have a chance to image this by orientating the line perpendicular to the road, and planting shots and receivers both on and besides the road, at sufficient offsets to reach the higher-velocity basement. See http://rayfract.com/samples/street_crossing.pdf .
- to increase lateral resolution when inverting first breaks with WET :

  - run *Smooth invert|WET with 1D-gradient initial model* as usual
  - select *WET Tomo|Interactive WET Tomography...*
  - click *button Edit velocity smoothing*
  - select *Manual specification of smoothing filter*
  - divide *Half smoothing filter width* by 2. E.g. change from 7 to 3.
  - click *Accept Parameters button*
  - click *Start tomography processing button* to redo WET inversion

- Tutorial camp1 shows how to build a custom layer-based initial model and use this for WET inversion. We still recommend to always use our default 1D initial model, with Smooth inversion method.
- For a new tutorial showing how to sort borehole traces by common receiver see a13r1dm.pdf .
- Review Detecting perched water bodies using surface-seismic time-lapse traveltime tomography (Gaines et al, SEG 2010). Includes WET velocity error analysis with checkerboard method.
- Thesis Stefan Jansen, Niels Bohr Institute, University of Copenhagen 2010 evaluates our Smooth inversion method with synthetic data for models of faults and small velocity anomalies, in Appendix C. Wavepath width used in Appendix E is too narrow for reliable interpretation with our software. Please use the default WET wavepath width, or even increase this, for the WET inversion to have a chance to robustly converge towards a meaningful interpretation, especially in case of bad picks.
- For a comparison between Wavefront refraction, Plus-Minus and GRM methods, see (Ali Ak, 1990). Traveltime data for one of the models used (irregular refractor) is available in your sample profile \RAY32\PALMFIG4. Invert this with our conventional Wavefront and Plus-Minus methods. See http://rayfract.com/help/manual.pdf , chapter 1.10.
- (Riddle, Hickey and Schmitt, SAGEEP 2010) show subsurface tunnel detection with ERT and SRT .
- see (Hickey, Ekimov and Hansen, SAGEEP 2009) for imaging of a collapsing dam .
- (Hickey, Schmitt and Sabatier, SAGEEP 2009) detect underground high-contrast voids with SRT .
- (Ali Ak, 1990) used Dr. Palmer's synthetic models to compare the Wavefront Refraction method (WR) with Plus-Minus and GRM. WR can image irregular refractor surfaces and detects sudden lateral change in velocity. WR depth calculations are independent of the refractor velocity.
- for frequency filtering, shot stacking, resampling, conversion between SEG-2 and SEG-Y etc. try the free Geogiga Front End . Write the processed shots to SEG-2 files and import into our software.

Version 3.18 released in December 2010 :

- **check first break picks for reciprocal errors in *Trace|Offset gather***, after *Smooth inversion*. See our tutorial http://rayfract.com/samples/GEOXMERC.pdf . Repick bad traces and redo *Smooth inversion*.
- **WET inversion (back projection routine) now uses multiple CPU cores**. Eikonal Solver used for forward modeling during WET still uses one core only. Overall WET runs up to 25% faster, for large datasets e.g. http://rayfract.com/samples/GEOXMERC.pdf and with **Intel Core i3 processor**, on Sony Vaio with 4 GB of RAM. No noticeable speedup for small datasets, e.g. LINE14 on Intel Core 2 Duo .
- *Model|Model synthetic shots…* **forward models traveltimes over your custom-built Surfer .GRD file, without preexisting seismic survey and without .PAR file**. Picked times are reset to these modeled traveltimes. Import ASCII.ASC or GeomTomCG .3DD dummy shots without picked times (all traces set to time -1), and then directly convert these dummy shots into synthetic shots modeled for your custom grid model. See http://rayfract.com/tutorials/palmfig9.pdf .
- *File|Export header data|Export Modeled Times to GeoTomCG .3DD…* allows export of synthetic picks to .3DD. Allows generation of .3DD with all traces set to -1, after above synthetic shot modeling, and with *File|Export Data Settings|Export dead traces to GeoTomCG.3DD* checked.
- *Window|Export ASCII Model of depth section* now regards *File|Export Data Settings|Export coordinates in feet*, when generating .CSV file for currently selected *depth section window*.
- *DeltatV|Delta-t-V Settings|Extrapolate output to all receivers* option extrapolates *Delta-t-V inversion* output to all receivers, beyond first/last CMP stations. This new option is disabled per default.
- *SHIFT-L command* (reverse polarity of current trace) now works in all *Trace menu gather displays*, not just in *Trace|Shot gather*. Select the *current trace* with *arrow-left* and *arrow-right keys*.
- *ALT-L command* (reverse polarity for all traces of currently displayed gather) works for all *gather displays* as well.
- *File|Import Data Settings|Round shot station to nearest whole station number* is unchecked per default for *File|New Profile…*, since version 3.17. If you specify **y coordinates different from zero** in *Header|Station*, you need to check this option for 3.17 and earlier versions. This ensures valid **correction of traveltimes for lateral shotpoint offsets**, during Smooth inversion and WET. You can leave this setting unchecked for version 3.18 . Be sure to reimport your shots after toggling this setting.
- *.GRD grid file and .CSV file selection* now works with newer matching *.PAR file*, without requiring you to update the *.GRD or .CSV time stamp* with TOUCH.EXE utility.
- Smooth inversion now always runs 20 WET iterations per default, even for low-coverage profiles with average shot spacing of more than 3 receiver spacings.
- *WET Tomo|WET tomography Settings|Scale wavepath width* may help to improve weathering layer resolution (less smoothing) for consistent first break picks. Uncheck *WET Tomo|WET tomography Settings|Disable wavepath scaling for short profile*, to enable adjustment. This wavepath width **scaling with picked time is preferred over minimal WET smoothing** (*WET Tomo|Interactive WET tomography|Edit velocity smoothing|Minimal smoothing)*, to prevent artefacts. See http://rayfract.com/SAGEEP10.pdf for up-to-date description of WET options and parameters.
- import of ASCII.ASC now regards the last line even if this is not terminated with a <carriage return> character (generated with ENTER key while editing).
- *Refractor|Midpoint breaks* , mapping traces to refractors with ALT-M : we now check if *Upper Layer Velocity Limits* increase with layer number. If not, we show an error message and ask to correct this.
- *Refractor|Midpoint breaks* , mapping traces to refractors with ALT-M : now works for large and dense data sets, with high *Weathering Velocity Limit*.
- all Rayfract® dialogs are now displayed in MS Sans Serif 8 pts, a bit smaller than previously.
- files **SHOTPTS.SHO, COORDS.COR and BREAKS.LST are stored into BACKUP subdirectory** of your profile, each time you select *File|Import Data…* . Generate these files manually via *File|Export header data* at appropriate times, to make sure they contain up-to-date information. Export these files into your own subdirectory e.g. MyBackup to ensure they are not overwritten.
- to ensure unique numbering for shots imported from multiple *Geometrics SeisImager/PlotRefa .VS files*, into the same Rayfract® profile database, we recommend pasting together all .VS files into one .VS file e.g. with Windows® WordPad or NotePad apps, and then import just this one .VS file.
- we now support importing with a *spread type* specifying fewer channels than actually contained in SEG-2 data files. E.g. specify *default spread type* "01: 24 channels" instead of "02: 48 channels" in *File|Import Data…*, to import only the first 24 channels from 48-channel SEG-2 files. **Do not try this with earlier versions of our software**, or you will corrupt the profile database and will need to reimport all the shots and geometry information and first break picks into a new profile database !
- use SEG2_EDIT utility http://pubs.usgs.gov/of/2003/ofr-03-141/ to rewrite SEG-2 files, with arbitrary trace ranges selectively removed. Use or define a matching *receiver spread type* with our software.

- default *WET wavepath width* is now always limited to 100%, even with bad/too late first break picks.
- we now support **import and inversion of ASCII.ASC with first break picks up to two seconds**. We increased the maximum allowed value for the following parameters :

  - *WET wavepath width* : maximum increased from 50% to 100%
  - maximum *sample count* imported per trace : 20,000 instead of 10,000
  - *trace gather displays* : trace amplitude, vertical time axis, horizontal station number axis can now be zoomed up to seven times, instead of six times
  - *DeltatV|Interactive Delta-t-V|CMP curve stack width* : max. 240 instead of 120
  - *Refractor|Midpoint breaks|ALT-M|CMP stack width* : new max. 240, old max. 120

- *DeltatV|Interactive Delta-t-V|Static Corrections|Inverse CMP offset power* helps to **filter out *DeltatV* artefacts for long/deep and high-coverage profiles**. Default value is 0.5. Decrease to 0.2 and increase *CMP curve stack width* to 120 or 240. Enable *DeltatV|Delta-t-V Settings|Weigh picks in CMP curves*. See http://rayfract.com/samples/GEOXMERC.pdf (data made available by GeoExpert Ag). This tutorial also shows **how to identify bad picks, in *Trace|Offset gather* and *Trace|Shot gather displays***.
- *Smooth invert|Smooth inversion Settings|Wide CMP stack for 1D-gradient initial model* lets you toggle *DeltatV parameter CMP curve stack width* between default value 120 and wide setting 240.
- assert failure with **expression deltatv_v0 > 0.0** can happen e.g. with marine streamer surveys, when using a small station spacing of 0.1m and spread type "36: 360 every 20". This allows for **arbitrary shifting of the receiver spread** during "roll-along" recording. With this assert failure, please
  - select *Delta-t-V|Interactive Delta-t-V* and click *Static Corrections button*
  - increase *Weathering crossover* to e.g. 50 and *Topography filter* to e.g. 500 stations
  - click *Accept button*, and run *Smooth inversion* or *Automatic Delta-t-V and WET inversion* as usual

- if Rayfract® 3.18 fails to start, with message mentioning VCOMP.DLL or error 0xc0000034 or "This application has failed to start because the application configuration is incorrect" or "Impossibile avviare l'applicazione specificata", install the **Microsoft Visual C++ 2005 SP1 Redistributable Package** from http://tiny.cc/b494e . This installs VCOMP.DLL into subdirectory of C:\WINDOWS\WinSxS . The updated http://rayfract.com/common/raywn318.exe installs VCOMP.DLL automatically.

- if Rayfract® does not accept your grey CmStick/CodeMeter dongle e.g. on Windows 7 64-bit and after reassigning disk partitions to drive letters, please
  - select Start button|Control Panel
  - type "Disk management" into field *Search Control Panel* , hit Enter key
  - left-click blue text Create and format hard disk partitions
  - plug in CmStick into any USB port
  - search for disk with blank Volume name, 39 MB Capacity and 0% Free
  - right-click disk symbol for this blank volume
  - right-click **menu item Change Drive Letter and Paths…**
  - click **Add… button,** select **drive letter** in drop-down box, click OK button

- http://rayfract.com/tutorials/palmfig9.pdf shows how to build the syncline model and forward model synthetic shots, as described in Palmer 2010 .
- http://rayfract.com/tutorials/fig9inv.pdf shows how using a closer *shot spacing* decreases the degree of non-uniqueness. E.g. shoot at every 2nd receiver instead of just at every 6th receiver. Increasing the *WET iteration count* from its default value of 10 or 20 iterations to 50 or 100 improves the resolution also. And we recommend using our 1D-gradient initial model, instead of pseudo-2D Delta-t-V initial model.
- http://rayfract.com/tutorials/epikinv.pdf shows interpretation of the "Broad Epikarst" model described by Jacob Sheehan in his JEEG March 2005 Seismic Refraction Tomography evaluation.
- resolution of WET and seismic refraction tomography in general decreases with increasing imaged depth. See e.g. http://rayfract.com/tutorials/thrust.pdf , D.J. White 1989 Two-Dimensional Seismic Refraction Tomography and J.G. Hagedoorn 1959 the Plus-Minus method of interpreting Seismic Refraction Sections Fig. 1 .
- for a recent comparison between our WET tomography and Dr. Palmer's GRM see http://www.univie.ac.at/ajes/archive/volume_102_2/marschallinger_et_al_ajes_v102_2.pdf
- Dr. Palmer assumes in his GRM method that the optimum XY spacing is constant for the whole profile. This is generally not true. See e.g. Hamdy H. Seisa 2007 , Fig. 1 & 2 (dipping refractor case).
- our Wavefront method automatically determines a laterally varying XY receiver separation. See Jones and Jovanovich (1985), Brueckl (1987) and Ali AK (1990). Wavefront considers local emerging

wavefront angles. A critically refracted ray is represented by first break and emergence angle at a receiver. Each reverse ray is combined with a matching forward ray, such that both rays surface from an approximated common refractor location.

- for our interpretation of the Palmer Mt. Bulga data set see http://rayfract.com/tutorials/mtbulga.pdf . The original traveltime data is available at http://rayfract.com/tutorials/mtbulga.zip . Process this with our free trial available at http://rayfract.com . Set *Station spacing* to 5m in *Header|Profile*. Next *File|Import Data…* . with *Import data type* Interpex Gremix .GRM. Now *Smooth invert|WET with 1D gradient initial model*. Apparently Dr. Palmer used a non-default Delta-t-V initial model and changed WET smoothing to *minimal smoothing* instead of leaving it at default *full smoothing*, in Fig. 2 of his EAGE Geophysical Prospecting January 2010 online paper. Also, he seems to have decreased *WET wavepath width* from its default setting, and only run a few WET iterations. With such poor settings, our WET inversion is effectively crippled, and WET output will be very similar to the starting model. As automatically proposed by our software, using a closer *shot spacing* would decrease the degree of non-uniqueness. E.g. shoot at every 2nd receiver instead of just at every 12th receiver. Increasing the *WET iteration count* from its default value of 20 iterations to 50 or 100 usually improves the resolution.

- Updated http://rayfract.com/tutorials/mtbulga.pdf with link to http://rayfract.com/tutorials/thrust.pdf . We did this thrust fault modeling specifically for Mt. Bulga data set. Also, we now recommend shooting at every 3rd, optimally at every 2nd receiver instead of every 6th receiver.
- to **batch-edit multiple SEG-2 files**, e.g. changing file descriptor field UNITS from FEET to METERS, and adding file descriptor field NOTE, please :

- download SEG2_EDIT.ZIP archive from http://pubs.usgs.gov/of/2003/ofr-03-141/
- unzip e.g. into local directory C:\SEG2_EDIT
- download SEGBATCH.ZIP from http://rayfract.com/tools/segbatch.zip
- unzip e.g. into local directory C:\TEMP, and open command prompt, with Start|Run… CMD.EXE
- copy your SEG-2 files *.SG2 into C:\TEMP, with COPY command
- create subdirectory C:\TEMP\BATCHOUT, with MD command
- edit SET_METERS.TXT response file for SEG2_EDIT, e.g. changing COMPANY and NOTE entries
- edit SETUNITS.BAT if necessary, to point to directory containing SEG2_EDIT.EXE executable
- run SETALL.BAT, to batch-edit all of your .SG2 files and write them to BATCHOUT subdirectory

- to **visualize an individual wavepath between one source and one receiver,** please :

- run our Smooth inversion with *menu Smooth invert*, e.g. for sample profile C:\RAY32\LINE14
- select *WET Tomo|Interactive WET tomography…*
- click *Select button* and specify last iteration e.g. VELOIT20.GRD
- set *Number of WET iterations* to 1
- click on *button Edit grid file generation*
- set *Write wavepaths to disk for shot no.* e.g. to value 3 for shot no. 3
- click on *button Accept parameters* and then *Start tomography processing*
- start up Surfer® and select *File|New..* . Specify form type "Plot document".
- select Surfer menu item *Map|Image Map…*
- select e.g. grid file C:\RAY32\LINE14\GRADTOMO\W003-024.GRD (shot no. 3, trace no. 24)
- double click on the generated black-and-white plot
- left-click on *Colors scale* and *Load button*
- select file Rainbow2.CLR in C:\RAY32 or your Golden Software Surfer Samples directory
- click on *button Open* and confirm with *OK*
- check *Interpolate Pixels* and *Show color scale.* Set *Missing Data* to white color and click *OK*
- select Surfer menu item *View|Fit to Window*
- you will then obtain a color plot of wavepath from shot no. 3 to receiver no. 24. The wavepath is centered on (black) time value of 0 milliseconds.
- save Surfer® plot with *File|Save As…* , as file C:\RAY32\LINE14\GRADTOMO\W003-024.SRF

- to **identify and fix bad shot positions**, please :

- select *Refractor|Shot breaks*
- uncheck *Mapping|Display raytraced traveltimes*
- uncheck *Mapping|Display synthesized traveltime curves*
- optionally check *Mapping|Gray picked traveltime curves*
- optionally check *Mapping|Dark Gray traveltime curves*
- use F7/F8 to browse picked traveltime curves

- the *vertical pick bar* indicates the *shot position* you specified during import
- so a *bad shot position* shows as a horizontal offset between traveltime curve minimum and pick bar
- use SHIFT+O keyboard shortcut for *Mapping|Check shot positions*, for automatic checking
- use *Smooth invert|Smooth inversion Settings|Strict shot position checking* for more accurate checking with above SHIFT+O command, in *Refractor|Shot breaks display*.
- export picked first breaks to .LST with *File|Export header data||Export First Breaks…*
- reimport identified bad shot(s) with correct *shot position* (specified in station numbers)
- import saved first breaks from .LST with *File|Update header data|Update First Breaks…*

- to manually **install the WibuKey driver 6.00a under Windows 7 32-bit or 64-bit,** please :

- logout from your current Windows 7 session, and unplug your green WibuKey dongle
- restart your PC, running Windows 7
- login as Administrator
- keep WibuKey dongle unplugged
- download http://www.wibu.us/files/user/wk6_00b/WkRuntime.exe
- run this WkRuntime.exe installer, confirming any prompts
- finally plug in your WibuKey dongle again
- wait for any balloon type messages to complete

Version 3.17 released in June 2010 :

- tested under **Microsoft Windows 7 64-bit on Intel Core i3 processor.** This works fine. Install our software as usual. Now go to http://wibu.com, download and install the **WibuKey Win 32 / Win 64 driver 6.00a** sized at 19 MB. Rayfract® versions earlier than 3.17 will not work with driver 6.00a.
- http://rayfract.com/common/raywn316.exe base installer prompts you to download WkRuntime.exe when run under Windows 7 64-bit. Confirm download with *Save button*, and run WkRuntime.exe, to install WibuKey 6.00a driver for 64-bit. Next run the latest rayup316.exe or rayup317.exe as supplied.
- once you run *Smooth inversion* at least once for a profile, and check *Smooth invert|Smooth inversion Settings|Allow unsafe pseudo-2D Delta-t-V inversion*, our *Delta-t-V menu* is reenabled again.
- for high-coverage profiles with at least 2,500 picked traces, you can enable *Delta-t-V* without first running *Smooth inversion*.
- all Surfer tomogram plots showing *Delta-t-V initial model* or *WET output based on Delta-t-V* will show a warning in the plot title saying **Delta-t-V initial model artefacts** !!!
- we strongly recommend using our *1D-gradient initial model* instead, via *Smooth invert|WET with 1D-gradient initial model*. *Delta-t-V initial model* may work better in some complicated cases of subsurface structure, such as a **thrust fault with fault zone** (see http://rayfract.com/tutorials/thrust.pdf) or with extreme topography, e.g. when imaging a dike. But in most situations of strong refractor curvature our *1D-gradient initial model* results in less artefacts. See http://rayfract.com/tutorials/broadepi.pdf .
- when using our *Delta-t-V initial model*, **test limiting the maximum exported Delta-t-V velocity to e.g. 3,000 or 4,000 m/s, to suppress artefacts**. See http://rayfract.com/tutorials/palmfig3.pdf .
- *Delta-t-V method* and *Midpoint breaks display* now support common-midpoint *CMP station numbers* smaller than -8,000 and larger than 8,000. Previously these were cached incorrectly, resulting in invalid CMP sorted trace gathers. The minimum/maximum station number range still is -10,000/10,000.
- *File|New Spread Type…* now allows defining custom spread types with **minimum receiver separation of up to 20 station numbers**. For underwater seismic refraction USR profiling, you may want to define a new spread type "36: 360 every 20", with 360 receivers and receiver separations "359*20". Then specify *station spacing* as e.g. 0.1m in *Header|Profile* instead of 2.0m. This allows for **arbitrary shifting of the receiver spread** during "roll-along" recording.
- *Delta-t-V|Interactive Delta-t-V…|Static Corrections* now allows *Weathering crossover* of max. 200 stations, and *Topography filter* of up to 2,000 stations. Also, these two parameters are not reset to default values any longer, during *Smooth inversion*.
- copy any *trace gather/refractor display/depth or velocity section* to Windows® clipboard. Select the section window with mouse left-click on its title bar, and press CTRL+C shortcut, to **copy window content as bitmap to clipboard**. Use CTRL+V shortcut in Golden Software Surfer, Microsoft Word, Microsoft Paint (MSPAINT.EXE) etc. to paste clipboard contents to current document.
- copy **bitmap of all opened section windows** to clipboard with CTRL+A shortcut.

- *Window|Export ASCII Model of depth section* lets you **write topography, refractor elevations and velocities to a comma-separated value .CSV file**. You may import this into Microsoft Excel etc. .CSV column 1 lists receiver station number, column 2 shows horizontal inline offset in meters.
- uncheck *Depth conversion|Display Wavefront positions* when viewing *Depth|Wavefront… section*, to **suppress display of estimated basement positions** with black triangles.
- we now explicitly pass the complete *grid line geometry* (min/max x/y coordinates, # of Lines) when calling into Golden Software Surfer® via Scripter. This ensures that you will never have to manually regrid the .CSV, when running our *Delta-t-V method*.
- when displaying traces with *Trace|Shot gather*, check option *Processing|Refresh shot breaks when picking traces* to enforce automatic refresh of *Refractor|Shot breaks display*, with updated traveltime curves. Leave this option unchecked for large data sets, and refresh manually with ALT-Y.
- for **stacking of SEG-2 trace files**, we recommend seg2_edit utility offered by Karl J. Ellefsen. See http://pubs.usgs.gov/of/2003/ofr-03-141/ and **section 3.3.4 Stack Traces, of the referenced report**. Create an auxiliary Rayfract® profile database, and import original unstacked shots plus stacked shots. Number stacked shots differently from original shots. Display shots in *Trace|Shot gather* as usual, and use F7/F8 to compare stacked with unstacked shots.
- **conversion of shot point position to station numbers and back to coordinates** is not trivial, especially in case of strong topography and varying receiver separation. To **ensure shot point x/y/z coordinates are specified correctly in the profile database**, import shots and update station and shotpoint coordinates as usual. Next

  - select *File|Export header data|Export Shot Point Coordinates…*
  - left-click *Create New Folder icon* on top right of *Export shotpoint coordinates dialog*
  - name this new folder e.g. export
  - navigate into this new export folder, and store SHOTPTS.SHO into this folder with *Save button*
  - open SHOTPTS.SHO e.g. with *Windows WordPad text editor*
  - ensure for all shotNr values (column 1) that shotX, shotY and shotZ are correct (columns 2 to 4)
  - fix shotX, shotY and shotZ in this editor session if required
  - save the fixed SHOTPTS.SHO to disk from within your editor, e.g. with *File|Save command*
  - *File|Update header data|Update Shotpoint coordinates…*and select fixed SHOTPTS.SHO file

  Our ***WET tomography*** requires **exact source and receiver positions**. A coordinate error of even just one centimeter may change the output visibly, especially at the bottom of the WET tomogram.

- uncheck *File|Import Data Settings|Round shot station to nearest whole station number* **before importing your data files**, to minimize above conversion error between shot station number and shot point coordinates. With this unchecked, shot stations are rounded to .5, e.g. to values 0.5, 1.0 or 1.5 . Version 3.17 of our software will uncheck this option automatically during *File|New Profile…* .
- improved *GeoTomCG .3DD* import routine now handles **duplicate traces** (same source and receiver coordinates) and empty lines. Empty lines are skipped. At the 2nd trace of two adjacent traces with same source and receiver coordinates, our import starts a new shot.
- once you edited *Trigger delay* in *Header|Shot* for one or more shots, be sure to export station coordinates via *File|Export header data|Export Station Coordinates…* to COORDS.COR and shot point coordinates including time terms to SHOTPTS.SHO via *File|Export header data|Export Shot Point Coordinates…*Save these files e.g. into a subdirectory named backup.
- if you then update first breaks via *File|Update header data|Update First Breaks…* , *Trigger delay* will be reset to 0 for all shots. Use *File|Update header data|Update Shot Point Coordinates…* with above SHOTPTS.SHO to **reapply your saved trigger delay values**.
- if your PC crashes with a Rayfract® profile opened, Rayfract® under rare circumstances may not allow you to create a new or open any existing profile database, showing messages saying **Raima Object Manager Error -905, -30** or similar. Please exit Rayfract® via *File|Exit* and
  - open *Windows Explorer window* with Windows key + E shortcut or via *Start|Run…* Explorer.exe
  - navigate into directory C:\RAY32\DAT
  - delete files rdm.taf, vista.taf, and user1.log
  - restart Rayfract® with *desktop icon*, and retry *File|Open Profile…* or *File|New Profile…*
- *temporary traveltime grid files* for negative receiver station numbers named R-????.GRD are now deleted during *File|Open Profile…* .
- for our SAGEEP10 short course tutorial see http://rayfract.com/SAGEEP10.pdf . This includes introductory **slides describing Smooth inversion and relevant WET and Delta-t-V parameters**.
- http://rayfract.com/help/function_keys.pdf replicates the table shown in Rayfract® help menu

- updated tutorials http://rayfract.com/tutorials/line2.pdf and http://rayfract.com/tutorials/sapri12.pdf , both now using *station spacing* 5m and *Default spread type* 10: 360 channels .
- updated tutorial http://rayfract.com/tutorials/thrust.pdf explains how to build your own model grid with Golden Software Surfer® and then generate synthetic traveltimes by forward modeling propagation of synthetic shots with the Rayfract® Eikonal solver.
- review Determining depth of blast induced damage in a mine wall (J.A. Singer et al. 2009) and Enhanced coastal geotechnics with integrated marine seismic reflection and multi-source, extended array refraction (Robert Whiteley, Matthieu Bardout and Simon Stewart 2010; includes synthetic model with velocity inversion)

Version 3.16 released in March 2010 :

- **we do not support running our software under Windows 98 and Windows NT any longer**. When started up under Windows 98 or Windows NT, Rayfract® 3.16 will display an error message recommending using Windows XP and will then shut down again.
- support import of **Micromed SoilSpy .SG2** SEG-2 files
- **disabled *pseudo-2D Delta-t-V inversion* with *Delta-t-V menu*, to suppress *Delta-t-V artefacts***. It is not possible to decide if an imaged velocity anomaly is for real or a Delta-t-V artefact. So to be safe we now just completely block Delta-t-V, in our latest version 3.16. See also http://rayfract.com/srt_evaluation.pdf , Fig. 1, http://rayfract.com/tutorials/depress.pdf , and http://rayfract.com/tutorials/palmfig3.pdf .
- you still can edit *Delta-t-V parameters and options* used by our *Smooth inversion* method, for determination of the *1D-gradient initial model* required by subsequent *2D WET Wavepath Eikonal Traveltime inversion*.
- support **zero-offset VSP Vertical Seismic Profiling** surveys. See http://rayfract.com/tutorials/vsp.pdf
- default *WET smoothing filter height* for *borehole spread/line profiles* is now limited to maximally twice the filter width, in grid cells. This gives better vertical resolution, of VSP surveys.
- when you invert your first break picks with *Smooth invert*, *WET Tomo* and *Delta-t-V menu commands*, we now always first **match *shot positions* to picked *traveltime curves***. If these don't match we show an error message and prompt you to adjust picks in *Trace|Shot gather*, adjust the *shot position* in *Header|Shot*, or reimport the shot (with corrected shot position) if required.
- in *Header|Shot*, *shot inline offset* may be set to maximally plus/minus one *station spacing* as defined in *Header|Profile*. If you need to change the *inline offset* to a larger amount, please reimport the shot with corrected *shot position* (in *station numbers*).
- new *SHIFT-O command* (Check shot positions) in *Refractor|Shot breaks* interactively pages through all shot-sorted traveltime curves and matches *shot positions* to picked *traveltime curves*, see above.
- *ALT-L command* (Remap all traces to refractors) in *Refractor|Shot breaks* and *Refractor|Midpoint breaks* now also matches *shots positions* to picked *traveltime curves*.
- new *SHIFT-S command* (Export first breaks to .LST) in *Trace menu* and *Refractor menu displays*. The current *trace gather display* or *refractor display* will stay open. This allows you to quickly save different picking versions to .LST .
- new *SHIFT-L command* (reverse polarity of current trace) in *Trace|Shot gather*. Select the *current trace* with *arrow-left* and *arrow-right keys*.
- we show the *trace amplitude zoom* in *trace gather displays* opened with *Trace menu*. The zoom is displayed on the *status bar* at the bottom of the screen, when navigating traces with *arrow keys*.
- *File|Export Data Settings|Export coordinates in feet* option. Check this and **export .COR, .SHO and .3DD files in feet instead of meters**. The unit is written to the first header line of these files. So you can e.g. export receiver coordinates in feet with *File|Export header data|Export Station Coordinates*, to a .COR file. Now update the .COR file with e.g. Windows Notepad editor, with receiver elevations in feet. Then reimport the .COR file with *File|Update header data|Update Station Coordinates*.
- adapted *import routine for GeoTomCG .3DD* files, to check for unit feet or meters in the .3DD . Feet values are always converted to meters, during import.
- our *Optim LLC SeisOpt and GeoTomCG .3DD import routines* **compute and initialize *shot depths*, based on *source and receiver coordinates*. We interpolate *line topography* between all receivers**. *Source z coordinate* in these input files specifies *elevation of shot hole bottom*. We determine *shot depth* as difference between interpolated topography (at source x coordinate) and shot hole bottom (source z coordinate). Source y and receiver y (see *Header|Station*) are always set to 0.0, during Optim LLC SeisOpt and GeoTomCG .3DD import. *Shot point elevation* shown in our SHOTPTS.SHO file is the

interpolated topography, at source x coordinate. Our tomography routine determines the actual *source elevation* by subtracting the shot hole depth from this shot point elevation. You can check the *source elevation* in *Header|Shot*.

- *shot hole depths* are initialized according to Geometrics PickWin/PlotRefa .VS files, during *File|Import Data…* .
- when importing *Geometrics PickWin/PlotRefa .VS files*, *x coordinate of first receiver* now can have any value and is not restricted any longer to 0.0 .
- fixed *shot depth* determination when importing multiple *.3DD files* from same *input directory*.
- fixed *shot position* determination when importing *uphole shots* from *GeoTomCG .3DD files* into *refraction spread/line* profiles. For earlier versions you need to correct the *shot position* during import.
- *Shot inline offset* in *Import shot(s) dialog* is regarded again, when importing shots into *refraction spread/line profiles*. This was broken in early 3.16, but works fine in version 3.15.
- improved matching of .GRM trace positions to profile database station numbers, during *File|Update header data|Update from Gremix .GRM files…* .
- *File|Import Data Settings|Round shot station to nearest whole station number* option. This option is enabled per default. Source *inline offset* (in meters) in *Header|Shot* is set to the difference between true and rounded shot location (in meters). If you uncheck this option before importing your data with *File|Import Data…* , imported shot stations are rounded to the nearest half-station number. E.g. to 0.5, 1.0, 1.5, 2.0 etc. As a consequence our *Trace|Offset gather display* is more useful for traces with short source-receiver offset and sources between receivers, at station numbers 0.5, 1.5 etc. **Reciprocal traveltime errors now are easier to identify, even for small common-offset values**. These errors can then be corrected for with *Header|Shot Trigger delay field*.
- when you invoke our *File|Import data… dialog*, station coordinates, shot point geometry and picked first breaks are exported and thus backed up automatically, to files COORDS.COR, SHOTPTS.SHO and BREAKS.LST. These files are stored in your profile subdirectory.
- *WET Tomo|WET tomography Settings submenu* now contains *WET options* formerly contained directly in *WET Tomo menu*.
- *Traveltime misfit* determined during WET forward modeling is now displayed as ***RMS error (in milliseconds) and normalized RMS error (in percent, of maximum picked time over all traces modeled).*** We determine ***RMS error and normalized RMS error*** (NRMSE) as described at http://en.wikipedia.org/wiki/Root_mean_square_deviation .*Mean unsigned errors* and *signed errors* are not shown any longer. These *RMS errors* are also stored in *.FIT misfit files*, e.g. VELOIT10.FIT for tomogram VELOIT10.GRD , in GRADTOMO or HOLETOMO profile subdirectories.
- *Line ID* specified in *Header|Profile*, *WET iteration* number or description of initial model, *RMS error* (in percent) and software version are now automatically shown on all Surfer-generated *velocity tomograms* and *wavepath coverage* plots.
- *negative shot hole depths* are not regarded any longer, when determining the *shot location* on a .GRD velocity grid during WET tomography.
- temporary *shot and receiver traveltime grids* (files S*.GRD and R*.GRD) located in profile subdirectories GRADTOMO, TOMO and HOLETOMO as well as in the *WET initial model directory* are always automatically deleted. **Earlier versions of our software do not delete these grid files if you abort Rayfract® via the Windows task manager**. Version 3.16 deletes these files the next time you open the profile you worked on when aborting. 3.16 keeps these grids if *WET Tomo|Interactive WET tomography… |Edit grid file generation|Delete traveltime grid files for last WET iteration* is unchecked.
- *WET Tomo|WET tomography Settings|Disable wavepath adjustment for short profile* option will automatically disable WET options *Adjust wavepath width and Scale WET filter height*, for short profiles with 48 or less receiver stations. This will **prevent WET artefacts due to bad first break picks**. Also, WET output will be smoother and more reliable, for short profiles. If your picks are good and you need to image detailed subsurface structure, you may uncheck *WET Tomo|WET tomography Settings|Disable wavepath adjustment for short profile*, as done implicitly for version 3.15 and earlier.
- option *Smooth invert|Smooth inversion Settings|Lower velocity of 1D-gradient layers*. Use this to set the *gradient-layer bottom velocity* to (top velocity + bottom velocity)/2, for each layer in the initial model. This option is disabled per default. Enable to **lower the velocity of the overburden layers**.
- option *Smooth invert|Smooth inversion Settings|Interpolate velocity for 1D-gradient initial model.* Enable to linearly interpolate the *averaged 1D-velocity profile* to determine the 1D-gradient initial model (as in previous versions). Disable for **constant-velocity initial overburden layers**, with the *layer-top velocity* assumed for the whole layer except the bottom-most 0.1m. This option is enabled per default, since *WET tomography* works most reliably with a smooth minimum-structure initial model.

- fixed correction of traveltimes for *lateral shotpoint offset*, when shot positioned exactly on last *receiver station* of profile.
- select *Depth|Depth conversion Settings|Link traveltime curves for Wavefront* to algorithmically shift and link traveltime curves for *Wavefront method*, instead of *Brueckl traveltime field regression*.
- select *Depth|Depth conversion Settings|Link traveltime curves for Plus-Minus* to algorithmically shift and link traveltime curves for *Plus-Minus method*, instead of *Brueckl traveltime field regression*.
- use *Depth|Depth conversion Settings|Skip reciprocal traveltime check* to suppress resetting of *regressed traveltimes* if local *reciprocal time estimate* deviates from mean reciprocal time for regressed or algorithmically shifted and linked traveltimes, for Wavefront and Plus-Minus methods.
- if your Golden Software **Surfer 9 Demo Scripter component does not start up under Windows Vista**, please uninstall Surfer 9 Demo and all other Surfer versions, download the latest version from goldensoftware.com, backup to USB flash and reinstall.
- if **Scripter fails to automatically open Golden Software Surfer under Windows 7**, please open Surfer interactively first and then retry e.g. Smooth invert with our software.
- when double-clicking our *desktop icon* multiple times, our software may try to start up multiple times. The first instance should succeed, but other instances will fail to start up, showing "***Internal error (40) An exclusive access conflicts with another exclusive access" message***. Click *Cancel button* to dismiss these and shut down these multiple instances.
- under rare circumstances our software may hang during *File|Open Profile…* . Open the *Windows Task Manager* with ALT-CTRL-DEL key combination. Now select *Image Name Rayfract32.exe* on *Processes tab* and click on *End Process button*. Restart Rayfract® via desktop icon, and retry the open.
- for a new paper by Laura V. Socco et al. comparing resistivity tomography with WET tomography and surface-wave analysis see http://www.citeulike.org/article/6511101 .
- for a new tutorial showing **interpretation of 5 shots into 12 channels** see http://rayfract.com/tutorials/EJEMPL3.pdf . Use our free trial to work through this. **We recommend using at least 24 channels for reliable WET interpretations**. Also, we recommend stacking of shots.

Version 3.15 released in May 2009 :

- more accurate determination of *layout start* and *shot position* (in station numbers), when importing Optim LLC SeisOpt or GeoTomCG .3DD files into *refraction spread/line* profiles, in case of strongly undulating topography.
- in *Trace menu gather displays*, the currently selected trace (with pick cursor) is kept selected, when zooming or unzooming the display. This allows for easier first break picking and correction. When opening a *trace display* window via *Trace menu*, the first (leftmost) trace and first break is selected automatically.
- higher zooming of trace amplitude, in *Trace menu gather displays*.
- corrected variable area trace display, with high zoom of trace time.
- better match of sample time at pick cursor (as displayed at bottom of screen), with trace time axis ticks, for high zoom of time.
- our installers RAYINSTL.EXE and RAYWN315.EXE correctly call the WIBU-KEY dongle driver installer, when run under Windows Vista. To invoke the driver installer manually, just run \RAY32\WIBUKEY\SETUP.EXE .
- improved matching of interpolated topography to source and receiver elevations. All sources and receivers with picked traces will be regarded during WET tomography, and will be displayed on the resulting velocity tomogram.
- updated tutorial http://rayfract.com/tutorials/sapri12.pdf . Answer prompt "Update profile station spacing ?" (shown during import of .VS file) with no, to preserve our custom *station spacing* of 2.5m .
- updated tutorial http://rayfract.com/tutorials/poisson.pdf . Specify elevation of 0.0 for all stations in *Header|Station*. Just fill in *z coordinate* for one station, and hit ENTER to extrapolate to all stations.
- Supports callling both Surfer 8 and Surfer 9 free demo, available at http://goldensoftware.com .
- traces in *Trace menu displays* are shifted by *delay time* and *trigger delay*, as specified in *Header|Shot* . This lets you **interactively correct shots for reciprocal errors caused by trigger delays**, visible in our *Trace|Offset gather display* .
- new *Trace Processing menu* option *Show picks on time axis*, without amplitude offset.
- new *File|Import Data Settings|Match .LST traces by station number* option. If this option is unchecked (by default), .LST traces are matched to database traces by channel number. If checked, .LST traces are matched to database traces by station number, during *File|Update header data|Update First Breaks* .

- to reimport **shots with changed *shot position* or *layout start* and keep current first break picks**, first store picks to .LST with *File|Export header data|Export First Breaks…* . Now reimport the shots. Next select *File|Update header data|Update First Breaks…* and specify the .LST just generated.
- to **suppress artefacts along tomogram edges (lateral smearing of velocity anomalies)**, WET sometimes works better with pre-3.05 settings :

  - uncheck *WET Tomo|Adjust wavepath width*
  - set *Degree of differentiation of Ricker wavelet* to 1 in *WET Tomo|Interactive WET tomography...*
  - adjust *wavepath width* : multiply by two for increased smoothing, divide by two for less smoothing

- for our expanded tutorial as presented at our SAGEEP 2009 short course see http://rayfract.com/SAGEEP09.pdf
- make sure that picked **traveltime curves for adjacent shots are at least somewhat similar** to each other, when reviewing them in our *Refractor|Shot breaks display*. See our tutorials at http://rayfract.com/tutorials/TUTORIAL.ZIP for typical traveltime curve sections.

  Refraction tomography is based on the **assumption that subsurface physical properties (related to propagation speed of seismic waves) have a quasi-continuous nature and do not vary randomly** on a small scale. Since first break energy incited at adjacent shot points propagates through the subsurface along similar wave paths and rays, the measured and picked traveltime curves for these shots should be similar.

Version 3.14 released in January 2009 :

- supports **import of SEG-2 formatted trace data files, into borehole spread/line profiles**.
- we assume that channel no. 1 was recorded for the deepest borehole receiver, of the current spread or chain. If not so please check import option *Turn around spread by 180 degrees* after selecting *File|Import Data…* .
- *Layout start* and *Shot pos.* station numbers are determined by dividing SEG-2 trace header fields RECEIVER_LOCATION and SOURCE_LOCATION for the first channel, with *Header|Profile* value *Station spacing*. We recommend using **negative station numbers and source/receiver z coordinates to indicate depth below topography**, as usual for borehole surveys.
- select *File|Import Data Settings|Import horizontal borehole survey or .3DD refraction survey*, before importing SEG-2 or .3DD data files for a horizontal borehole spread/line, with *File|Import Data...* .
- color traces shown in *Trace menu* gather displays, with new options in menu *Processing*. You may vary the color both of the variable area filling and of the signal outline. You may color shot traces by *source type*, as selected in *Header|Shot.*
- move the *picking cursor* ("plus" symbol) along the currently selected trace outline with up-arrow and down-arrow keys. Move the cursor to next left/right trace with left-arrow and right-arrow keys.
- **hit the space bar key to pick the first break for the current trace**, at the current sample (as indicated at bottom of display). Pick with the left mouse key to first select current trace and sample and then pick the first break at that position, in one operation.
- delete the first break pick for the current trace, with ALT-DEL. Use Shift-left mouse key to first select the trace and then delete the pick for that trace, in one operation.
- **sort traces by common shot-point station**, with our new *Trace|Shot point gather* display. This allows for **easy picking of shear-wave shots (recorded at the same shot point)**, if the sign-inverted waveforms are colored appropriately with above options. Alternatively, you may pick traces in our *Trace|Offset gather* display.
- our redesigned install scripts are now based on Inno Setup. The resulting **installable archives will run under Windows 64-bit versions**. After installing our software on a Windows 64-bit version with RAYWN314.EXE, you will be prompted to download and install the 64-bit WIBU-KEY driver software for Win64, from http://wibu.com/download.php . Click "English" at top of page, and then click "Software" and "User". Now scroll down to section with green WibuKey headline.
- after running the new RAYWN314.EXE installable archive, you will also be prompted to import your custom spread types (file \RAY32\REF\MYSPREAD.SPR), into the reinstalled reference database.
- updated tutorial http://rayfract.com/tutorials/line2.pdf . Check *File|Import Data Settings|Keep same Layout start for consecutive shot files* before importing the data, for compatibility with the included .LST / .SHO /.COR files. These assume that the first receiver is assigned to station number 1, and not 0.

- updated tutorial http://rayfract.com/tutorials/clud1.pdf . Uncheck *File|Import Data Settings|Default distance unit is meter*, to specify distance unit feet before importing the Optim LLC SeisOpt data. This file format does not specify the distance unit, so you must specify this explicitly with our *File menu*.
- *WET Tomo|Blank low coverage after each iteration* is now unchecked, when opening an existing or creating a new profile database. You may uncheck this manually for version 3.12, to prevent excessive blanking at the bottom of the tomogram.
- if after importing data our software shows geometry errors, with the inline offset between stations either not increasing or increasing by twice the *station spacing* specified in *Header|Profile*, check *File|Import Data Settings|Keep same Layout start for consecutive shot files* and redo the import. This should help to correctly determine *layout start* and *shot position* in station numbers, for each shot being imported.
- for a new tutorial showing data import and *Smooth inversion* of our TRA9002 data set (Val de Travers, made available by GeoExpert ag), see http://rayfract.com/tutorials/TRA9002.PPT. For the input data see http://rayfract.com/samples/TRA9002.ZIP .

Version 3.12 released in November 2008 :

- *File|Export header data|Export Traces to GeoTomCG .3DD...* lets you generate GeoTomCG .3DD files. Use *File|Export Data Settings* options to configure :
- *File|Export Data Settings|Export dead traces to GeoTomCG .3DD*
- *File|Export Data Settings|Gather traces by common-receiver station* as primary key. This option lets you reverse walkaway VSP surveys into uphole shot surveys and vice-versa. To be able to import these reversed uphole shots into a refraction spread/line profile, please make sure that the shot points for the original walkaway VSP survey are positioned at whole station numbers, of the refraction spread. If this setting is unchecked (as per default), traces are sorted by common shot number (primary key) and receiver station (secondary key), when exporting to GeoTomCG .3DD format.
- *File|Export Data Settings|Secondary trace key is shot point elevation*, for common-receiver primary key and borehole spread/line. For refraction spread/line type profiles, the secondary sort key for common-receiver primary key is always shot x for refraction shots, and shot z for uphole shots. So make sure to correctly mark uphole shots in *Header|Shot*.
- you may **constrain the refraction tomographic inversion of one surface based refraction spread/line profile, with uphole shot surveys recorded for multiple in-line boreholes**. An uphole shot survey may optionally be obtained by reversing a walkaway VSP survey, as described below (steps 5. to 10.). This will further increase the degree of angular coverage of the subsurface with rays and wave paths, and make the tomographic inversion even more robust. Be sure to reverse each walkaway VSP survey with a separate borehole spread/line profile.

- test .3DD export and import with our http://rayfract.com/tutorials/coffey04.pdf tutorial and data set :

  0. create new refraction spread/line profile COFFEY04 with *File|New Profile…*, *station spacing* 2.5m
  1. download input files from http://rayfract.com/tutorials/coffey04.zip . Copy COFFEY04.ZIP into \RAY32\COFFEY04\INPUT, unzip to obtain ASCII.ASC, COORDS.COR and SHOTPTS.SHO .
  2. *Start|Run…* WORDPAD.EXE text editor, and delete shots 1 to 13 so the ASCII.ASC contains uphole shots 14 to 37 only.
  3. import ASCII.ASC into profile COFFEY04. Update with COORDS.COR and SHOTPTS.SHO.
  4. export uphole shot traces as .3DD, sorted by common-receiver station
  5. create new borehole spread/line profile with *File|New Profile…* and *station spacing* of 1m
  6. import above .3DD reversed uphole shots, resulting in walkaway VSP shots
  7. export VSP shot traces as .3DD, sorted by common-receiver station
  8. create new refraction spread/line with *station spacing* 2.5m
  9. enable *File|Import Data Settings|Import horizontal borehole survey or .3DD refraction survey*
  10. import above .3DD reversed VSP shots, resulting in uphole shots
  11. export these regenerated uphole shots as .3DD, sorted by common shot
  12. export uphole shot traces from profile created in step 0., as .3DD and sorted by common shot
  13. compare .3DD files generated in steps 11. and 12. with file comparison utility. These should be identical.
- *Smooth invert|WET with constant-velocity initial borehole model* now writes Surfer .GRD files to \RAY32\<your profile name>\HOLETOMO subdirectory for uphole refraction surveys, instead of GRADTOMO subdirectory. This makes it easier to compare output with *Smooth invert|WET with 1D gradient initial model* output.

- no more blanking at the bottom of WET tomogram after last iteration for horizontal borehole surveys, in areas not covered by wave paths (regarding WET parameter *Envelope wavepath width*).
- when you select *File|Import Data Settings|Import horizontal borehole survey or .3DD refraction survey*, and then import a .3DD refraction survey into a refraction spread/line type profile database, our .3DD import routine now updates shot hole depths correctly. Edit shot hole depths manually in *Header|Shot*, for versions 3.10 and 3.11 of our software, after import of .3DD surface refraction survey.
- during *File|Exit* without having opened any SEIS32.DBD profile, an early version 3.12 of our software displays an error message "Raima Object Manager Error: -6018 / database swap failed". You can safely ignore this message. Also, this issue has been fixed for the final version 3.12.
- **if Smooth inversion imprints wavepaths on the velocity tomogram and the tomogram is too noisy**, especially when processing a short (one spread with 48 or less receivers) and low-coverage refraction spread/line (shot spacing of 5 or more average receiver spacings), you may want to uncheck *Smooth invert|Scale WET filter height*, and uncheck *WET Tomo|Adjust wavepath width*. Then redo the Smooth inversion, with *Smooth invert|WET with 1D gradient initial model*. This will give smoother inversion output, especially if the refraction spread/line is steeply inclined (more than 30 degrees) and for low-velocity weathering layers.
- *WET Tomo|Blank low coverage after each iteration* blanks low coverage areas at tomogram bottom after each iteration, except the last one. Low coverage means less than 10 percent of maximum grid coverage. This blanking option is enabled per default.
- *WET Tomo|Blank low coverage after last iteration* blanks low coverage areas at tomogram bottom after the last iteration. This option is disabled per default.
- *WET Tomo|Blank below envelope after each iteration* blanks the tomogram below envelope of all wavepaths, after each iteration except the last. Regards WET parameter *Envelope wavepath width.* This is disabled per default, when creating a new profile or opening an existing profile database. Also, we recommend to leave this blanking option disabled, since it blanks excessively and may suppress meaningful output.
- *WET Tomo|Blank below envelope after last iteration* blanks the tomogram below envelope of all wavepaths, after the last WET iteration. Regards WET parameter *Envelope wavepath width* . This is enabled per default.
- above four new WET blanking options help to suppress the imaging of high-velocity and low-velocity artefacts at the bottom of tomograms, as described e.g. by Jacob Sheehan et al. in http://pubs.usgs.gov/sir/2005/5160/PDF/Part1_2.pdf , Fig. 3a .
- see http://nsg.eage.org/details.php?pubid=10557 for "Seismic characterization of an Alpine site" by L.V. Socco et al., published in EAGE Near Surface Geophysics August 2008 issue. Correlates WET tomography with reflection seismic, surface wave and pseudo-2D shear wave interpretation plus downhole measurement.
- to fix geometry errors in SEG-2 trace data files we recommend the free XVI32 hex. editor. See http://www.chmaas.handshake.de/delphi/freeware/xvi32/xvi32.htm . Be sure to always edit SEG-2 files in overwrite mode and NOT insert mode. Otherwise you damage the file structure (pre-computed offsets to next field). To correct the shot position, update SEG-2 field SOURCE_STATION_NUMBER or SOURCE_LOCATION for the first channel (CHANNEL_NUMBER 1) of the problem shot. To fix the layout start, edit SEG-2 field RECEIVER_STATION_NUMBER or RECEIVER_LOCATION of the first channel.
- to correct the SEG-2 UNITS field from FEET to METER, overwrite "FEET" with "METE", without the trailing 'R', using above XVI32 hex. editor. Otherwise you damage the SEG-2 file structure.
- some PC's have a "non-standard" LPT port implementation and/or do not supply enough power to the dongle. If the WIBU-KEY driver software does not recognize your LPT parallel port WIBU-KEY dongle (e.g. after (re)installation), please proceed as described in http://rayfract.com/help/rayfract.pdf , bottom of page 90 and top of page 91, to adjust the LPT port address used by the WIBU-KEY driver. **Make sure to always uncheck box *System default* on the *Setup tab* of the WIBU-KEY control panel applet, and always specify the *Port address* explicitly** (even if MSINFO32.EXE shows default value of 0378 Hex). Leave *Bus type* as ISA and *Bus index* as 0.
- if the above does not help with your LPT port WIBU-KEY communication, please try connecting a printer with a parallel port printer cable plugged into the LPT WIBU-KEY or unplug such a cable.
- if the LPT dongle is still not recognized by the WIBU-KEY driver, you may introduce a delay factor to prevent a timeout, in case of too low power supply to the dongle. See also http://support.wibu.com/en/faq/faq.html#Delay . Pleas
  - download the .ZIP archive http://rayfract.com/dongle/diaglpt.zip from our web site.
  - *Start|Run* "explorer.exe" (without enclosing ""), to open Windows Explorer .
  - create a directory \ray32\wibukey\diaglpt on your laptop's hard disk, with Windows Explorer.

- copy diaglpt.zip file into this directory, and unzip it e.g. with WINRAR utility.

Now slow down the communication speed between the LPT port and the WIBU-KEY dongle :

- open a DOS command prompt via *Start|Run* “cmd.exe” (without the enclosing “”).
- change the current directory of that prompt with command line "cd \RAY32\WIBUKEY\DIAGLPT".
- navigate with Windows Explorer to your \ray32\wibukey\diaglpt directory, as created above.
- click on w2k_delay4.reg, and confirm the two prompts.
- switch to the DOS prompt as opened above
- enter command line "WKU32 RESET ALL"
- then try to start up Rayfract® again.

If this does not help, please repeat the above last four steps for all other .reg files in your DIAGLPT directory. ...delay12.reg will slow down the communication speed the most.

If your LPT WIBU-KEY dongle is still not recognized by the WIBU-KEY driver, please contact us for an USB key license upgrade offer.

Version 3.11 released in July 2008 :

- new refractor mapping option in *menu Mapping* : *Blue direct wave first breaks* to color direct wave traveltime curve segments in blue instead of the default orange. This may help with certain display devices (depending on lighting) and when printing sections.
- new *Depth conversion menu* option *Blue weathering bottom*, to plot refractor 1 elevation and velocity in solid blue color instead of the default black. Refresh displayed depth and velocity sections with ALT-Y.
- improved matching of trace positions in Interpex Gremix .GRM and BREAK.LST files, to receiver stations in the currently opened profile database. Input file positions are now always matched to the closest database receiver station, when updating header data with *File|Update header data menu* items.
- *branch point pick bar* is now always displayed and updated correctly in *Refractor|Shot breaks*, without a second bar ghost showing at a previous position.
- uphole shot traces are not mapped to a refractor any longer, in *Refractor|Midpoint breaks display*.
- corrected tutorial http://rayfract.com/tutorials/coffey04.pdf for imaging of an uphole refraction survey. Uphole shots (inverted walkaway VSP downhole shots) are combined with surface refraction shots.
- fixed an assertion failure during computation of the initial model, for uphole refraction surveys. If you encounter this problem with an early version 3.11 of our software, please download and install your corrected RAYUP311.EXE installable archive. See our e-mail instructions.
- combination of walkaway VSP with surface refraction requires resorting VSP traces by common borehole receiver, to create synthetic (inverted) uphole shots. See above for version 3.12 release notes, describing automated conversion of walkwaway VSP surveys to uphole shot surveys and vice versa..
- you may want to combine walkaway VSP (shots at topography, receiver string in borehole) with crosshole shots, recorded with the same borehole receiver string. We support such a geometry in the same GeoTomCG .3DD survey file, with one or more overlapping borehole receiver spreads (in same borehole) and arbitrary shot positions. These shots may be positioned on the topography or in any number of other boreholes or tunnels.

Version 3.10 released in June 2008 :

- we now support import of GeoTomCG .3DD files for horizontal borehole surveys and surface refraction surveys. Just select *File|Import Data Settings|Import horizontal borehole survey or .3DD refraction survey*, before importing the data with *File|Import Data...* .
- our import routine automatically **detects the averaged minimum distance between receiver stations for the current input file, and lets you update the** *station spacing* **to this new value**.
- import of Optim LLC SeisOpt, Geometrics SeisImager PickWin/PlotRefa .VS, GeoTomCG .3DD and Interpex Gremix .GRM files has been improved, with missing dead/unpicked traces and strongly undulating topography. Missing traces are matched by inline offset, to spread receiver channels and line topography as specified in the input file, for other shots and traces.
- import of Geometrics SeisImager PlotRefa .VS now works with irregular receiver spacing.
- geometry error messages shown during data import will not swamp you any longer. Adjusting *Header|Shot* field *station spacing* by a few percent may help. Also, you may want to toggle *File|Import Data Settings|Allow missing traces* and *File|Import Data Settings|X coordinate is corrected for*

topography already, if appropriate. Uncheck this option for Geometrics SeisImager .VS and Interpex Gremix .GRM, and check it for Optim LLC SeisOpt and GeoTomCG .3DD files.

- new *File|Import Data Settings|Swap borehole x with z* option. Enable this to swap coordinates during import of .3DD files, and during export of SHOTPTS.SHO and COORDS.COR files.
- our *Refractor display parameter dialog* (invoke wit ALT-P, in *Refractor|Shot breaks*) now allows entering a *Minimum station number* value in range –10000 to +10000. Also, we now allow adjusting the *Minimum time* to a value larger than 0, for borehole spread profiles.
- two new **conventional method refractor mapping** options in *menu Mapping* : *Undercorrect picks for shot point offset* will not fully correct first break picks for shot point offset (from nearest integer station), during Wavefront and Plus-Minus interpretation. This allows for diving waves, even at near-shot point receivers. Use this option to obtain less distorted corrected traveltime curves, in case of a thin low-velocity overburden.
- *Regard mapping for shot offset correction* uses our earlier first break pick correction method if enabled, based on trace-to-refractor mapping and resulting refractor velocities. If unchecked, picks are corrected based on source-receiver geometry only, not regarding the trace-to-refractor mapping. Picked traveltimes are corrected for *shot point offsets* from nearest receiver station. Thus our traveltime field regression method (preliminary step of our *Wavefront and Plus-Minus conventional methods*) can reliably reduce recorded traveltime curves to one pair of forward/reverse curves, for one or multiple sections of the whole profile database.
- during *WET inversion* and forward modeling, first breaks are always corrected for lateral shotpoint offsets, based on source-receiver geometry only and disregarding any earlier trace-to-refractor mapping. *Inline shot point offsets* (from *shot station*) and *shot depth* are not corrected for, during *WET inversion*.
- for accurate shot timing, we recommend GISCO piezoelectric trigger switches. See http://www.giscogeo.com/pages/seixptr.html .
- for our new tutorial showing sub-bottom river imaging between two boreholes, see http://rayfract.com/tutorials/b8b9.pdf .

Version 3.09 released in May 2008 :

- WET options are now correctly initialized, when creating a new borehole spread/line profile database. To ensure correct settings for 3.08, create profile with *File|New*…. Now reopen with *File|Open*… .
- we now support traveltime tomography of first breaks recorded for **Walkaway VSP surveys, with a constant-velocity initial model**. See http://rayfract.com/tutorials/walkaway.pdf
- improved support for **combination of uphole shots with surface refraction shots**, both recorded with surface refraction receiver spreads. See http://rayfract.com/tutorials/coffey04.pdf . You may generate uphole shots from multi-offset VSP downhole shots as follows :

  - import VSP shots (GeoTomCG .3DD format) into Rayfract® borehole spread profile. See above WALKAWAY.PDF tutorial .
  - export traces as ASCII.ASC with *File|Export header data|Export First Breaks as ASCII...* .
  - resort traces by common borehole receiver station, e.g. with Microsoft Excel spreadsheet software .
  - correct order of columns : swap column “Shot station #” with column “Receiver station #” .
  - reset column “Shot number” to same value, for all traces recorded by a common borehole receiver.
  - export updated column data from Microsoft Excel, to generate ASCII.ASC with uphole shots.
  - now import the surface refraction shots into a new Rayfract® refraction spread profile .
  - finally import the .ASC uphole shots into this same refraction spread profile .
  - invert the data with our Smooth inversion method as shown in above COFFEY04.PDF tutorial .

- our Smooth inversion routine will now automatically depth-extend the 1D gradient initial model (generated from surface based refraction shots) to elevation level of deepest uphole shot.
- when marking shots as uphole shots in *Header|Shot* by selecting *Shot Type* “Uphole shot”, field *Uphole time correction term* is now set to the new default value of 0.01 msecs. instead of 10 msecs.
- when changing back *Header|Shot* field *Shot Type* to “Refraction shot”, shot traces are now correctly marked as refraction shot traces in the profile database. *Uphole time correction term* is reset to 0.
- we now support **Smooth inversion of uphole refraction surveys with a constant-velocity initial model**. See http://rayfract.com/tutorials/coffey04.pdf .
- *Delta-t-V|Delta-t-V Settings|Regard Uphole picks for Delta-t-V inversion* is not supported any longer, since correct interactive estimation of *Header|Shot* field *Uphole time correction term* is too difficult.

- please uncheck *Delta-t-V|Delta-t-V Settings|Regard Uphole picks for Delta-t-V inversion* before processing uphole refraction surveys with older versions of our software.
- the WET continuation prompt as shown after display of initial model now allows aborting the inversion.
- our *Refractor display parameter dialog* (invoke wit ALT-P, in *Refractor|Shot breaks*) now allows entering a negative *Maximum station number*.
- *Refractor|Shot breaks* does not link traveltime curves to shot station any longer, for borehole spreads.

Version 3.08 released in April 2008 :

- uncheck *File|Import Data Settings|Keep same Layout start for consecutive shot files*, to determine layout start and shot position station numbers by division of positions specified in Geometrics SeisImager .VS, Interpex Gremix .GRM, Optim LLC SeisOpt and GeoTomCG .3DD files, with the *station spacing* as specified in *Header|Profile* . This import option is unchecked per default when creating new profiles.
- WET continuation prompt is displayed on top of all other windows, and cannot get "lost" any longer.
- *Smooth invert|Scale WET filter height* is now supported for crosshole surveys, but is unchecked per default. Option *WET Tomo|Adjust wavepath width* is not allowed for crosshole surveys any longer.
- Both of these options are activated when you create a new refraction spread profile.
- updated PDF help topics available at http://rayfract.com/help/rayfract.pdf
- You may rerun our Smooth inversion with a slightly different 1D gradient initial model :

  - shut down Rayfract® and Golden Software Surfer® applications with *File|Exit* .
  - Rename directory \RAY32\<profile name>\GRADTOMO to ...\DFLTGRAD, in Windows Explorer
  - restart Rayfract, reopen profile database with *File|Open* .
  - check *Delta-t-V|Delta-t-V Settings|Process every CMP offset*, for sharper layer boundaries
  - select *Smooth invert|WET with 1D gradient initial model*
  - proceed as in chapter 1.4 of our manual at http://rayfract.com/help/manual.pdf
  - once WET inversion finishes, open both VELOIT10.SRF or VELOIT20.SRF (as stored in subdirectories ...\DFLTGRAD and ...\GRADTOMO) in Surfer and tab through them.

Version 3.07 released in March 2008 :

- shows Root Mean Square RMS error (standard deviation) of misfit between modeled and picked times. Both mean and RMS error of signed and unsigned misfit are displayed after WET inversion or forward modeling, and written to VELOITXX.FIT files (VELOIT10.FIT for VELOIT10.GRD).
- correctly imports topography from Geometrics PlotRefa .VS files if unpicked traces missing from .VS , or if .VS contains shots recorded with not just one spread but multiple overlapping receiver spreads .
- when importing uphole shots, the traveltime curve minimum position may deviate from the hole position, by up to the depth of the shot. Specify shot depth in ASCII.ASC column or during import.
- topography now is always imaged correctly (no blank pixels below topography) on WET tomograms, even with widely spaced shots and receivers.
- *Grid menu* transformations “Convert grid file between feet and meters” and “Turn around grid file by 180 degrees” now correctly transform both the velocity tomogram VELOITXX.GRD and the corresponding coverage grid COVERGXX.GRD .
- *File|Import Data Settings|Keep same Layout start for consecutive shot trace files* is now disabled (unchecked) per default. With this option disabled, our import routine determines layout start and shot position directly from the SEG-2 trace headers. See below, notes for version 2.65 . SEG-2 trace header fields SOURCE_STATION_NUMBER and RECEIVER_STATION_NUMBER override fields SOURCE_LOCATION and RECEIVER_LOCATION.
- *Trace menu* items Shot gather, *Midpoint gather* and *Offset gather* now show trace cursor attributes at bottom of display, when moving the pick cursor with left/right/up/down arrow keys. We show station, trace, shot, channel, sample, time and amplitude attributes .

Version 3.06 released in February 2008 :

- **scales WET *smoothing filter height*, with depth below topography**. This ensures better resolution of weathering layer, and fewer artefacts at bottom of WET tomograms. Also, the misfit between modeled and picked first breaks decreases faster during WET inversion (with fewer iterations).
- startup diagnostics allow for date change across time zones when validating database schema \RAY32\REF\PROTO32.DBD .
- all recently added Smooth inversion and WET settings are appended to .PAR files.
- Shot point symbols (inverted red triangles) are now plotted on top of receiver symbols (grey diamonds), on WET tomograms. See Grid menu options.
- *File|Update header data|Update from Gremix .GRM files…* correctly matches .GRM shot and receiver positions with profile database station numbers.
- for Smooth inversion 3.06 of an Optim LLC SeisOpt® data set made available by FUGRO WEST see http://rayfract.com/tutorials/clud1.pdf .
- for imaging of a reactived landslide in Austria see http://rayfract.com/tutorials/gs0801.pdf .

Version 3.05 released in January 2008 :

- automatic adjustment of *WET wavepath width* for each trace, based on the picked time. For low coverage surveys (wide shot spacing), you may want to disable this new option in menu "WET Tomo".
- WET parameter *Degree of differentiation of Ricker wavelet* has been changed to the new default value 0 (former default value 1). Also, the Ricker wavelet weighted wavepath modeling has been corrected, for value 0.
- these improvements lead to more robust WET output, even with difficult data sets showing e.g. velocity inversions in overburden and at a high WET iteration number. Also, the weathering layer is better resolved, and basement velocity is imaged more reliably.
- to restore **pre-3.05 WET default parameters** :

  - uncheck *WET Tomo|Adjust wavepath width*
  - select *WET Tomo|Interactive WET tomography…*
  - for a new profile, click on *button Reset* to reset the WET *wavepath width*
  - reset *Degree of differentiation of Ricker wavelet* to 1
  - Adapt other WET parameters such as *WET iteration count* and *velocity smoothing*
  - click on button *Start tomography processing* and continue as usual

- pre-3.05 WET default parameters may work better for some special applications, such as cavity imaging and with a wide shot spacing (higher than 6 average receiver separations).
- we now correct first breaks for lateral shotpoint offsets, during WET inversion and forward modeling over Surfer .GRD files.
- two new *Refractor mapping menu* options, for coloring of shot sorted traveltime curves. You may display all curves in gray, or color each shot curve by source type, as selected in *Header|Shot*.
- to adjust minimum/maximum velocities used for Surfer® color coding of velocities :

  - start up Surfer e.g. via desktop icon
  - select Surfer menu item *File|Open...*
  - select WET tomogram e.g. VELOIT20.SRF file, located in \RAY32\<your profile> subdirectories :
  - GRADTOMO (Smooth inversion) or
  - BOREHOLE (Crosshole survey) or
  - TOMO (Pseudo-2D Delta-t-V initial model based inversion).
  - select Surfer menu item *View|Object Manager*
  - double-click on *Image Map* label shown at left of Surfer® VELOIT20.SRF plot
  - click on *Colors* color bar
  - Set *Minimum* to e.g. 500 m/s, *Maximum* to e.g. 5000 m/s and click on OK twice
  - select Surfer menu item *File|Save* to store edited VELOIT20.SRF tomogram

- our new tutorial http://rayfract.com/tutorials/sapri12.pdf shows interpretation of a Geometrics SeisImager™ PickWin .VS file, with version 3.05 Smooth inversion.
- when creating new spread types with *File|New Spread type…*, MYSPREAD.SPR is written to \RAY32\REF again instead of \RAY32\BIN

- resets interactive WET *wavepath width* to default value, when importing new data or when running our Smooth inversion.

Version 3.04 released in December 2007 :

- More robust routines for database creation and automated revision of old profiles
- Improved automatic determination of default wavepath width, for very shallow refraction surveys with a short receiver spacing / for closely spaced boreholes.
- Improved startup diagnostics. If the RAYFRACT32.EXE is started up in the wrong directory, or the prototype database schema \RAY32\REF\PROTO32.DBD is invalid, the software will display an according error message. Once you dismiss this message, the software will shut down again.
- *Menu Smooth invert* contains new borehole survey option *Beydoun weighting for borehole WET* to enable/disable Beydoun weighting.
- *Menu Smooth invert* offers new borehole survey option *Coverage grid shows unweighted hit count*. If unchecked, the coverage grid shows the hit count of each grid cell, scaled by Beydoun weighting.
- To generate GeoTomCG .3DD input files required by our new crosshole tomography routine, we recommend using **TomTime picking software**, available from GeoTom LLC. Contact Daryl Tweeton at tweetond@tc.umn.edu or at dtweeton@giscogeo.com . TomTime reads all common seismograph formats, and offers versatile frequency filtering and display options. See

  http://giscogeo.com/pages/seixgott.html

  for more information. TomTime also allows easy picking of shear-wave first breaks. Alternatively you may want to upgrade to our latest version 3.14 which now supports import and picking of SEG-2 borehole spread/line traces, and shear-wave picking.

Version 3.03 released in November 2007 :

- Profile creation and database update now work again correctly, on non-English language Microsoft Windows installations
- When running our software under Microsoft Windows® 2000, be sure to always uncheck *File menu* item *Call batch from PIF file*, immediately after starting up Rayfract®. Otherwise database revision and spread type import/export routines will fail to complete.
- For instructions showing processing of a crosshole data set see http://rayfract.com/tutorials/igta13.pdf .
- To disable dynamic Beydoun weighting during WET inversion of borehole surveys, check *Smooth invert menu* option *Precompute static Beydoun weight matrix*. Static weighting assumes that each pixel is affected by all wave paths. Dynamic weighting does not make this assumption. Static weighting is more conservative, and a compromise between dynamic weighting and no weighting at all.

- To specify elevations for all profile shot and receiver stations in a surface based refraction survey :

  - select *Header*|*Station*
  - browse station records with F7/F8 . If x/y/z are correct already exit with ESC key.
  - otherwise click on *button Reset coordinates and v0*
  - leave x/y coordinates empty for all stations
  - enter elevation z for a few non-adjacent stations
  - you do not need to enter z elevation for all stations
  - now click on *button Interpolate coordinates and v0*
  - Next you may reopen the station editor with *Header*|*Station*. Now browse station records with F7/F8 to check the interpolated elevations. Also, x/y coordinates have been generated automatically.
  - To specify a known/fixed elevation at more stations before interpolation, you need to first click on *button Reset coordinates and v0*. Then reenter the elevation at all relevant stations, and click again on *button Interpolate coordinates and v0*.

  - Alternatively, generate COORDS.COR file with *File*|*Export header data*|*Export Station Coordinates…*
  - edit the COORDS.COR e.g. with Wordpad or Notepad text editors
  - reimport the edited COORDS.COR with *File*|*Update header data*|*Update Station Coordinates…*

- To display GeoTomCG .3DD files in a readable way, please proceed as follows :

  - select *Start|Run*
  - enter "Wordpad.exe" without the enclosing "" and click OK
  - select *File|Open* in Wordpad program
  - navigate to your \RAY32\DOC directory and select e.g. IGTA13.3DD

- To enable or disable posting and labeling of shot points and/or receivers on WET tomograms, check or uncheck the corresponding menu item in *menu Grid* before starting our Smooth inversion.
- You don't have to redo the Smooth inversion to redisplay WET tomograms with/without posting and labeling of shot points and/or receivers. Proceed as follows instead :

  - check or uncheck corresponding items at bottom of *menu Grid*
  - select *Grid|Image* and contour velocity and coverage grids...
  - select desired WET tomogram grid file e.g. VELOIT20.GRD (output after 20 WET iterations), stored
  - in profile subdirectories GRADTOMO (Smooth inversion),
  - BOREHOLE (crosshole survey) or
  - TOMO (pseudo-2D Delta-t-V initial model).

- To generate a desktop shortcut for easy Rayfract® startup :

  - Left-click *Start menu*, All Programs, Rayfract32
  - right-click menu item Rayfract32 and select "Copy" command
  - minimize all windows
  - right-click on Desktop and select *Paste Shortcut command*

Version 3.02 released in October 2007 :

- Implements improved weighting/preconditioning for Smooth inversion of crosshole surveys. Velocity artefacts/anomalies at grid corners and at grid edges/directly adjacent to boreholes are suppressed. See Beydoun and Mendes 1989 "Elastic Ray-Born L_2-Migration/Inversion" with abstract at http://www.blackwell-synergy.com/doi/abs/10.1111/j.1365-246X.1989.tb00490.x .
  See also Luo and Schuster 1991 "Wave-equation Traveltime Inversion" Appendix B, with abstract at http://link.aip.org/link/?GPY/56/645/1 . Luo and Schuster describe this weighting as "… Another modification is to use a preconditioned gradient (search) direction (formula). This preconditioning compensates for geometrical expansion (Beydoun and Mendes, 1989)".
  The high sensitivity of WET to velocity variations directly at source/receiver is welcome for surface refraction surveys, since receivers are located close to the shot point in this case. For borehole surveys, the closest receiver is in the other hole. So velocity variation at source/receiver cannot be measured reliably in this case, and needs to be suppressed during tomography processing. More weight is given to the central portion of the subsurface section, located between the two boreholes. The fundamental assumption is that for borehole surveys, there are no "large" velocity variations, i.e. minimum velocity smaller than e.g. 50% of maximum velocity. For surface refraction surveys, minimum velocity (directly below topography) may be as small as 10% or less of maximum subsurface section velocity (in basement).
- Further optimized WET based inversion of surface refraction surveys. Smooth inversion of our LINE14 sample profile runs another 10% faster under Windows XP SP2 on an Intel Core 2 Duo processor.
- *Channel numbers* and *station positions* in *Header|Receiver* now always correspond to ASCII.ASC input file values, even when limiting the offset during import.
- Import option *Turn around spread* now works for all input file formats. Also, shot positions are inverted correctly, relative to the receiver spread.
- Import options *Turn around spread* and *Limit offset* may not be selected both at the same time.
- WET *smoothing filter* size now is determined based on average receiver spacing instead of the profile station spacing.

Version 3.01 released in September 2007 :

- We now support crosshole traveltime tomography, based on a constant velocity initial model which is iteratively refined with WET Wavepath Eikonal Traveltime tomography processing.
- We have tested our new crosshole tomography routine with sample survey files made available by our Spanish client I.G.T. International Geophysical Technology. These files are formatted as GeoTomCG .3DD files. See http://rayfract.com/samples/borehole.zip
- For instructions on crosshole data interpretation, see file BOREHOLE.TXT included in borehole.zip .
- We currently regard X and Z coordinates only for crosshole surveys. Y coordinates as specified in GeoTomCG input files are not regarded and are assumed to be all zero.
- If you want us to support your crosshole data format and samples, you are welcome to send us these files, as long as you have a current support contract.
- Also, we now support posting and labeling of both sources and receivers on WET velocity plots. See new items at bottom of Grid menu.
- We offer a new routine *File|Update header data|Import synthetic breaks from .LST*
- For IGTA13 crosshole data set (see above BOREHOLE.ZIP and BOREHOLE.TXT) a synthetic model is available at http://rayfract.com/samples/swiss.zip . This allows determination of vertical and lateral velocity resolution in WET output.

Version 2.75 released in August 2007 :

- Supports importing Geometrics SeisImager™ .VS files generated with Plotrefa and Pickwin modules. Specify distance unit feet by unchecking File|Import Data Settings|Default distance unit is meter.
- Import routine supports trace gaps with more than three adjacent missing traces
- Improved robustness of Wavefront method when processing low-coverage data sets
- WET tomography will regard a receiver station if traces have been picked for that station only
- File|Update header data|Update from Gremix .GRM allows for missing traces in .GRM files
- File|Update header data|Update First Breaks from .LST now matches .LST traces to profile database traces by station number instead of trace number. So you can

  - import e.g. SEG-2 shots (always all traces imported) into one profile
  - import e.g. SeisOpt files with missing traces into another profile
  - select File|Export header data|Export First Breaks to generate .LST file with SeisOpt picks
  - update first profile with File|Update header data|Update First Breaks.. and the .LST just generated.

Version 2.74 released in July 2007 :

- Improved compatibility with Microsoft Windows® Vista™. Axis ticks are now always labeled correctly, in time/depth/velocity sections.
- Comes with latest version 5.20b of WIBU-KEY dongle driver software.
- To activate Setup, Context and Update tabs in the WIBU-KEY control panel applet 5.20, left-click on the small icon to the left of the dialog title bar and select "Advanced Mode".
- We now display the current WET iteration number, at left bottom of Rayfract® main window.
- WET Tomo menu options are now enabled before starting with first Smooth inversion or pseudo-2D Delta-t-V and WET inversion.
- The receiver spread layout start is now always rounded correctly to the nearest whole integer station number, when importing shots into a profile database.
- When importing multiple e.g. Interpex Gremix .GRM files in one session, the layout start for each shot in each .GRM file is now determined correctly, based on receiver locations specified in the .GRM files.
- When updating from version 2.72 or 2.73 to version 2.74, your custom receiver spread types are now imported automatically during installation of 2.74, from file \RAY32\REF\MYSPREAD.SPR .
- Every time you open a profile database and spread types referenced have been validated, these are exported automatically to file MYSPREAD.SPR in your profile directory. Also, MYSPREAD.SPR is updated whenever you import one or more additional shots into the same profile database.
- Version 2.74 has been recompiled with Microsoft Visual C++ 2005. Smooth inversion for our sample profile LINE14 runs about 10% faster as a consequence.
- Also, 2.74 comes with updated versions of Birdstep RDM database utilities, for initializing, checking, revising, import into and export from profile databases.

- Use our Trace|Offset Gather display to check your first breaks for consistency regarding reciprocal traveltimes. For the same offset and midpoint (station number), first breaks picked (red crosses) should collapse onto a single pick. If these are displayed on the same trace but vertically offset from each other, such picks violate the traveltime reciprocity principle which states that traveltime is invariant to exchanging source and receiver between two constant measuring stations. Browse offsets with F7/F8 in Trace|Offset Gather. Browse individual traces with left arrow/right arrow keys. Disregard reciprocal errors at small offsets, regard reciprocal errors at large offsets.
- For a short description of the mathematical theory behind our Delta-t-V and XTV inversions, see http://rayfract.com/xtv_inversion.pdf
- A recent Karst study done at University of Florida compares Rayfract® Smooth inversion with Geometrics SeisImager™, Optim LLC SeisOpt® Pro and core data. See http://rayfract.com/07-2353.pdf
- For a recent USGS publication comparing GeoTomo LLC GeoCT-II with Rayfract® see http://pubs.usgs.gov/sir/2006/5166/

Version 2.73 released in May 2007 :

- Supports Microsoft Windows® Vista™, Windows XP, Windows 2000, Windows 98 SE. Follow Vista instructions on how to download and install WINHLP32.EXE, to enable Rayfract® help file display.
- Allows import of Optim LLC SeisOpt files. You may generate SeisOpt data files e.g. with W_GeoSoft WinSism 10. For Rayfract® import of SeisOpt files, disable File|Import Data Settings item "Default distance unit is meter" to specify distance unit feet. Disable setting "Default time unit is seconds", to specify time unit milliseconds.
- If there are dead traces missing from SeisOpt or Interpex Gremix input data files, these missing traces are regenerated during import automatically for the active part of the receiver spread type specified.
- You now can browse/add/import/export receiver spread types in menu File without opening a database.
- If during import of data files with File|Import Data… Rayfract® shows an error message and you switch to another application, the cursor may display as an hour glass when you try to reactivate Rayfract®. Be sure to click once or twice on the Rayfract™ icon shown in the task bar at the bottom of your display, to reset the cursor to the normal arrow and to unlock our software. This issue has been fixed for version 2.73.
- We recommend to refine Smooth inversion WET output by increasing the WET iteration count to e.g. 100 or 200 iterations. See our tutorials
  http://rayfract.com/tutorials/line01pt.pdf
  http://rayfract.com/tutorials/line2.pdf

- For a recent survey imaging subsurface velocity below a street using Rayfract® pseudo-2D Delta-t-V and Smooth inversion, see http://rayfract.com/samples/street_crossing.pdf
- For a recent study comparing a published Palmer GRM interpretation with Rayfract® Smooth inversion, see http://rayfract.com/papers/eg374whiteleyeditcheck.pdf . This paper also includes interpretation of a low coverage synthetic data set, with four different methods.

Version 2.72 released in January 2007 :

- We have implemented "File" menu functions for export/import of receiver spread types. Please note that you need to open any profile e.g. LINE14 first, to enable this. Also, whenever you define a new spread type, all spread types are exported to file \RAY32\REF\MYSPREAD.SPR. Spread types are stored in the reference database (directory \RAY32\REF, files SEISRF32.*), and not in the individual profile databases. So any custom spread type defined or imported is available for all profile databases.
- We offer a new Header|Profile field "Min. horizontal separation [%]". This field defines the minimum horizontal station offset applied during coordinate interpolation, in percent of the inline station offset. You may want to leave this field at its default value of 25%, for most recording geometry situations.
- Also, we now support posting and labeling of shot points. See new options at bottom of Grid menu.
- Our software supports again reading of .PAR parameter files generated with version 2.64 and earlier versions.

Version 2.71 released in December 06 :

- This updated version features a new XTV parameters dialog, in menu Delta-t-V. You may enable modeling of constant velocity layers with a modified Dix inversion, and/or with Intercept time layer inversion. The XTV method also supports modeling of constant velocity gradient layers (with our existing Delta-t-V method), and has been described by Roland A. Winkelmann in his 1998 thesis, as done with Professor Helmut Gebrande in Munich. We recommend enabling XTV inversion for high coverage profiles only.
- Once you have specified your preferred XTV parameters in above dialog, you may then carry out a pseudo-2D inversion, with our existing Delta-t-V menu item "Interactive Delta-t-V". This inversion algorithm has been generalized and now supports the XTV method.
- The XTV parameters are now correctly loaded from the profile database, when displaying the XTV dialog. Also, the valid range of the three numeric parameters has been changed. The minimum velocity ratio required for application of the Intercept time layer inversion now ranges from 1.01 to 2.5. And the sum of the two velocity step parameters may not exceed 100 percent.
- XTV parameters chosen are now written to the .PAR file, during Delta-t-V inversion. And the inversion type used for each layer is written to the last column of the .CSV file.
- We have improved our automated database revision routine. The revision log is now written to file SEIS32.REP in the profile database directory.

Version 2.70 released in November 06 :

- We have adapted our WET imaging such that the topography is now imaged correctly, for receivers beyond the first/last shot position. Please note that imaged velocity shown below such receivers is not very meaningful, since the all-important weathering velocity and thickness can't be determined below these receivers. Since there are no shot points positioned close to these receivers.
- This version features a first try at our implementation of the XTV inversion as described by Roland A. Winkelmann in his 1998 thesis. See Delta-t-V settings submenu. Use for high coverage surveys and at your own risk only.
- The SEIS32.BLN blanking file generated during Delta-t-V inversion will now be corrected for a non-zero "Profile start offset" as specified in Header|Profile.
- Also, our Rayfract(tm) software now correctly imports extrapolated shot branches generated during conventional Wavefront and Plus-Minus interpretation of profiles with a minimum receiver separation of two or more station numbers.

Version 2.66 released in November 06:

- We offer a new Grid menu command "Convert elevation to Depth below topography..." for conversion of elevation section grids to depth sections grids.
- Also, the station header V0 (weathering velocity) is now updated automatically, when remapping traces to refractors in Refractor|Shot breaks, and when smoothing crossover distances in Refractor|Midpoint breaks. If consecutive Wavefront or Plus-Minus interpretation fails saying "Bad traveltime field" after 10,000 regression iterations, please proceed as follows :
  - select Refractor|Shot breaks or Refractor|Midpoint breaks
  - disable Trace mapping|Automated updating of v0
  - proceed as described in above manual.pdf, chapters 1.8 & 1.9 (Shot breaks) or chapters 1.12 and 1.13 (Midpoint breaks)

- In menu WET Tomo|WET tomography Settings, we offer a new option "Update imaged grid depth". This option is enabled by default. If enabled, the grid depth will be updated after each tomography iteration. Otherwise, the imaged grid depth will stay the same as for the initial model.
- Wavefront and Plus-Minus modeling parameters "Overburden filter" and "Base filter width" can now be set to maximally 20 and 30 station numbers, respectively.

Version 2.65 released in September 06 :

- The "original input file" name is shown correctly again, in Refractor|Shot breaks.
- Forward modeling of traveltimes with our optimized Eikonal Solver runs about 15% faster.
- Our SEG-2 binary trace data import routine now should correctly import most trace data files, even if the trace data start is not rounded up to the next a 32-bit (double word) block boundary, as prescribed by the SEG-2 standard.
- We offer a new "Image and contour velocity and coverage grids..." function, in menu "Grid". Use this function for imaging of Surfer(tm) grid files as generated during previous inversions.
- Interactive Delta-t-V export settings dialog offers a new option “Gridding method”. Select one of "Natural Neighbor", "Nearest Neighbor", “Delaunay Triangulation" and "Minimum Curvature".
- Menu “Grid” offers another new function “Grid and image Delta-t-V .CSV file…”. This function regards the current setting of Delta-t-V export option “Gridding method”. So you may grid the same .CSV with alternative methods, without having to redo the Delta-t-V inversion.
- If you disable the new setting "File|Import Data Settings|Keep same layout start for consecutive shot trace files", layout start and shot position are determined directly from SEG-2 trace header fields SOURCE_LOCATION and RECEIVER_LOCATION. The layout start is rounded to an integer station number, and the shot position is shifted by the resulting offset (less than half a station spacing).
- We recommend the latest version 3.22 of the INTERPEX IXSEG2SEGY utility, for frequency filtering and picking of traces. This version now correctly preserves SEG-2 trace header fields SOURCE_STATION_NUMBER and RECEIVER_STATION_NUMBER. See http://www.interpex.com . These fields override fields SOURCE_LOCATION and RECEIVER_LOCATION.
- We have deprecated our pseudo-2D Delta-t-V inversion, and now recommend to always at least trying our Smooth inversion method, based on a 1D gradient initial model. See e.g.

  http://rayfract.com/help/manual.pdf
  http://rayfract.com/tutorials/palmfig3.pdf
  http://rayfract.com/tutorials/depress.pdf
  http://rayfract.com/tutorials/broadepi.pdf

Version 2.64 released in May 2006 :

- Delta-t-V inversion once again works fine with parameter “Regression over offset stations” set to values higher than 7. This was broken in version 2.62.
- Displaying and picking shot traces with up to 10,000 samples now works correctly. Previously, this did not always work, with more than 5,000 samples per trace.
- Data import routine supports merging of binary trace data files with ASCII first break picks as supplied in GEOMETRICS .BPK pick files, even if columns 5 and 6 of the .BPK are not separated by white space characters. Column 5 is assumed to contain “0.0” (without the enclosing “”).
- “Import shots” dialog offers new option “Detect shifted 32-bit floating point sample data start”. This option was implicitly enabled up to now, but did not always work. Use this option if imported binary shots don’t show any coherent signal, in Tace|Shot gather.
- SEG-2 import routine supports DMT SUMMIT 32-bit floating point traces.
- Improved support for import option “Limit offset”. Use for improved imaging of shallow subsurface (e.g. weathering layer), if the data was recorded with too long receiver spreads and too many channels.
- New function “Reverse polarity” in menu “Trace processing”.
- When opening or moving any other window on top of trace gather window, mouse cursor is not reset any longer when the underlying trace gather is repainted.
- The “original input file” displayed in the title bar of the Trace|Shot gather window is out of sync with the actual shot no. displayed. This is shown correctly in Refractor|Shot breaks. Rest assured that this display bug does not affect geometry handling and inversion of your data in any way.
- The Surfer(tm) Kriging gridding method sometimes generates artefacts, such as false high velocity anomalies directly below the topography. If you want to experiment with different algorithms than the default Kriging method, please download archive http://rayfract.com/common/scripts.zip to a temporary directory e.g. C:\TEMP. Now unzip the archive in C:\TEMP and proceed as described in the included README.TXT. We offer scripts for gridding methods "Natural Neighbor", "Nearest Neighbor", “Delaunay Triangulation" and "Minimum Curvature".

- For optimum coverage of the subsurface with seismic energy, we recommend to employ overlapping receiver spreads. See http://rayfract.com/help/overlap.pdf and http://rayfract.com/help/overlap.txt .
- To suppress velocity artefacts, we strongly recommend using our Smooth inversion method. See http://rayfract.com/pub/srt_evaluation.pdf and http://rayfract.com/tutorials/broadepi.pdf .
- Wavefront and Plus-Minus inversion may abort with a message saying "Refractor coverage may be too low or too short". Please record more (far offset) shots for this profile, and use a shorter receiver spacing. Also, use longer receiver spreads, with more channels. Our Plus-Minus and Wavefront inversions include a preliminary processing step called "traveltime field regression" which reduces basement refractor first breaks to a single set of forward and reverse traveltime curves (Brückl 1987). This data reduction step requires a certain data density. If too few shots were recorded, or the receiver spacing was too wide and/or receiver spreads were too short, this reduction algorithm may not be able to reduce the data set.
- The traveltime field regression algorithm works best if all sources and receivers are positioned at whole station numbers. So you may want to reimport your shots into a new profile, with a more appropriate "Receiver spread type", e.g. "13: 48 every2nd".
- Also, overburden refractor first breaks are interpreted with the conventional intercept time method, for adjacent reversed shot pairs. This step requires a certain data density as well. Please note that such low coverage problems do not arise with our Smooth inversion and Delta-t-V and WET inversion, since these methods do not require you to map traces to refractors at all.
- When importing first breaks from Interpex Gremix .GRM files or ASCII.ASC files, these files need to specify first break pick times for all receivers specified in the spread type used. If a trace cannot be picked (data is too noisy or the trace is dead), please specify a time of -1, meaning "not picked".
- Import of ASCII.ASC shots may show an error message ""Shot position of shot nr. … is not at traveltime curve minimum !" The import routine detects for inline shots the two channels with the smallest first break picks. If the shot is not positioned between these two channels, above message is shown and the shot is not imported. You may want to repick traces or edit the .ASC such that the shot position is located between the two smallest first break times. You may need to introduce "artificial" picks for near-shot traces which you did not pick previously.
- To update the Windows help file topics shown in menu "Help", please proceed as follows :
  - Download http://rayfract.com/help/rayfract.hlp to a directory on your PC, e.g. C:\TEMP.
  - Open a Windows Explorer window via Start|Run…, enter "Explorer" and hit RETURN.
  - Navigate to your C:\TEMP directory. Select file RAYFRACT.HLP with left mouse key.
  - Press CTRL-C or select Edit|Copy .
  - Navigate to your \RAY32\HELP directory, e.g. C:\RAY32\HELP.
  - Press CTRL-V or select Edit|Paste . Confirm the "Confirm File Replace" prompt.

  Context sensitive popup help (in dialogs) will work for a recently updated Rayfract™ installation only.
- If the word feet or meter is contained in a header line of a .PRN, .SHO or .COR file, the shot and receiver positions and coordinates in that file are assumed to be specified in that distance unit. See http://rayfract.com/help/ln14feet.zip for sample files, specified in feet.
- You may want to limit the maximum Delta-t-V velocity to a value lower than the default 5,000 m/s. Use "Export Option" parameter "Max. velocity exported", in Delta-t-V|Interactive Delta-t-V. This parameter is regarded by both pseudo-2D inversion and Smooth inversion.

Version 2.63 released in December 2005 :

- WET grid caching algorithm correctly decides whether to cache all receiver grids in RAM, or whether to write all grids to disk, depending on the amount of free RAM available.
- Integrated optimized memory manager (MicroQuill SmartHeap version 8), for improved data processing performance.
- Inversion will recognize if a profile is too long, and will recommend splitting the profile into two parts. This may happen e.g. in case of many short overlapping receiver spreads, and short maximum offset between shot point and receiver.
- New edit field "Profile start offset" in Header|Profile. Use this field to specify a horizontal inline offset different from 0.0, for the first profile receiver. This start offset value will be used by subsequent Delta-t-V and WET imaging, and is shown on the horizontal X axis.
- New WET setting "Write grids for every iteration".

- The maximum imaged depth has been extended to 70 km, and there is not any longer a limit on the maximum first break pick time.
- The “Annotation parameters” dialog allows selection of X/Y axis Line type “Dashed line”/”Dotted line”/”No line” and ticks type “Major & Minor”/”Major ticks”/”No ticks”.

Version 2.62 released in August 2005 :

- Significantly improved Delta-t-V internal static corrections. During a second pass of statics computation, ray emergence angles are now regarded.
- Additional Delta-t-V setting “Suppress velocity anomalies”. Use for medium to high coverage profiles, to suppress noise and processing artifacts.
- New Delta-t-V setting “Process every CMP offset”. Use for medium to high coverage profiles, high S/N ratio and flat subsurface layering, for increased vertical resolution.
- SEG-2 import routine now supports importing 32-bit floating point traces generated with Interpex IXSEG2SEGY utility.
- Numeric field entry always allows adding more digits without first having to delete the whole entry.
- When toggling Delta-t-V static correction methods “surface consistent” and “CMP gather specific”, just one subsequent run of the Delta-t-V inversion is required, for stable output.
- A few minor bugs have been fixed.

Version 2.61 released in March 2005 :

- Improved robustness of WET tomography implementation.
- Maximum number of WET iterations increased to 999.
- Updated and optimized database subsystem.
- Correctly regard “off end” shots during WET inversion, located at a distance of up to two station spacings, from first/last profile receiver.
- Mapping of traces to refractors in Midpoint breaks display (Refractor|Midpoint breaks) now works as advertised in our manual, with spread type “13: 48 every 2nd” and a station spacing of half the true receiver separation. See http://rayfract.com/tutorials/line2.pdf .