Plot first 8 WET runs for MARINE_L03 Steepest-Descent multiscale WET on one page with latest 5.02 Pro / Oct 2025 :

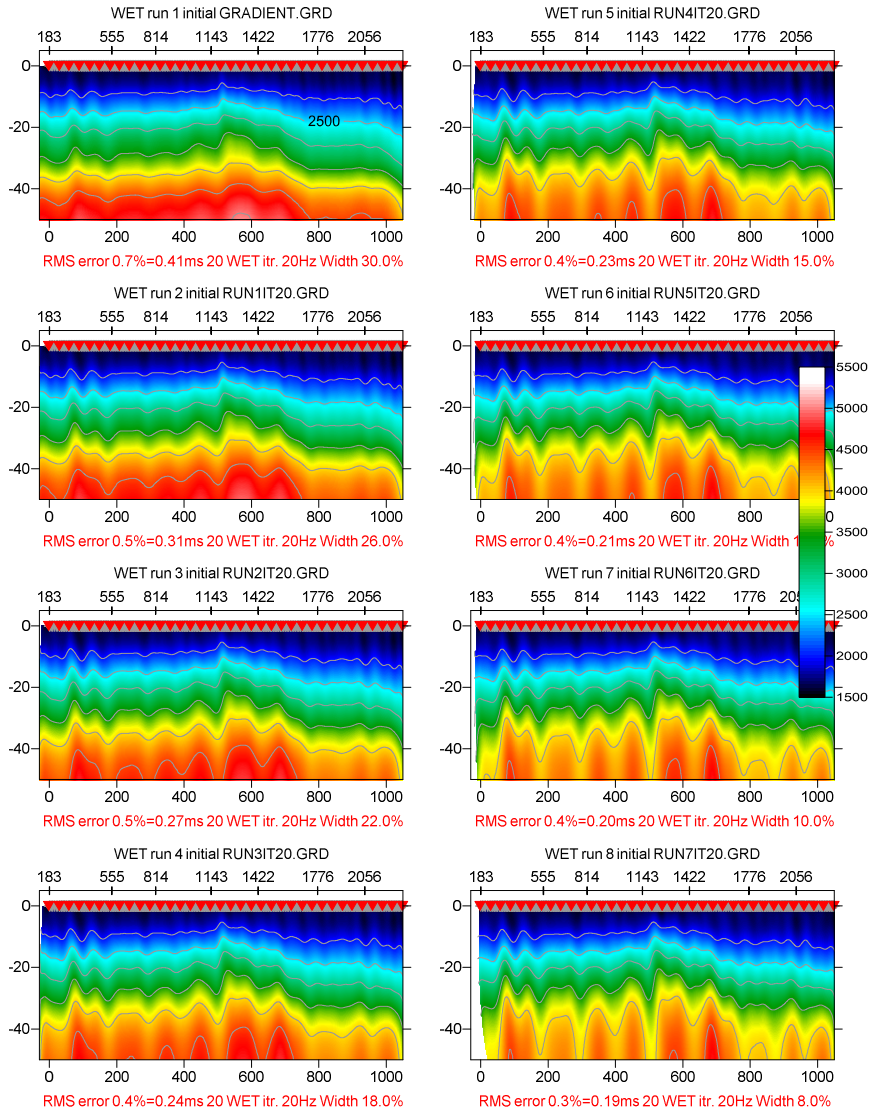


Fig. 1 : plot first 8 Steepest-Descent WET runs (20 WET iterations per run) for profile MARINE_L03 multiscale WET on one page with new Grid menu command ***Plot multiple WET runs on one page*** available with our 5.02 Pro version. The laterally averaged 1D-gradient starting model for first WET run is shown in Fig. 6.

As shown in Fig. 1 and in Fig. 2 our new Grid menu command ***Plot multiple WET runs on one page*** available with our 5.02 Pro version allows visualizing multiple runs in one Surfer plot. This multiscale plot enables easy comparison of multiple WET runs (here using 20 Steepest-Descent WET iterations per run) and allows to visually determine how well the multiscale WET inversion is working with your current WET and WDVS settings. Observe the monotonically decreasing RMS error shown in red in each plot's caption, with increasing run number as shown in each plot's title. See also our 2025 expanded abstract available at https://rayfract.com/pub/geoconvention2025_abstract.pdf and our other marine refraction profiles at https://rayfract.com/tutorials/SR6_multiplot.pdf and https://rayfract.com/tutorials/SR6.pdf and https://rayfract.com/tutorials/L-230_VS.pdf . See page 10 for step-by-step instructions with multirun WET settings shown in Fig. 21 and Fig. 22.

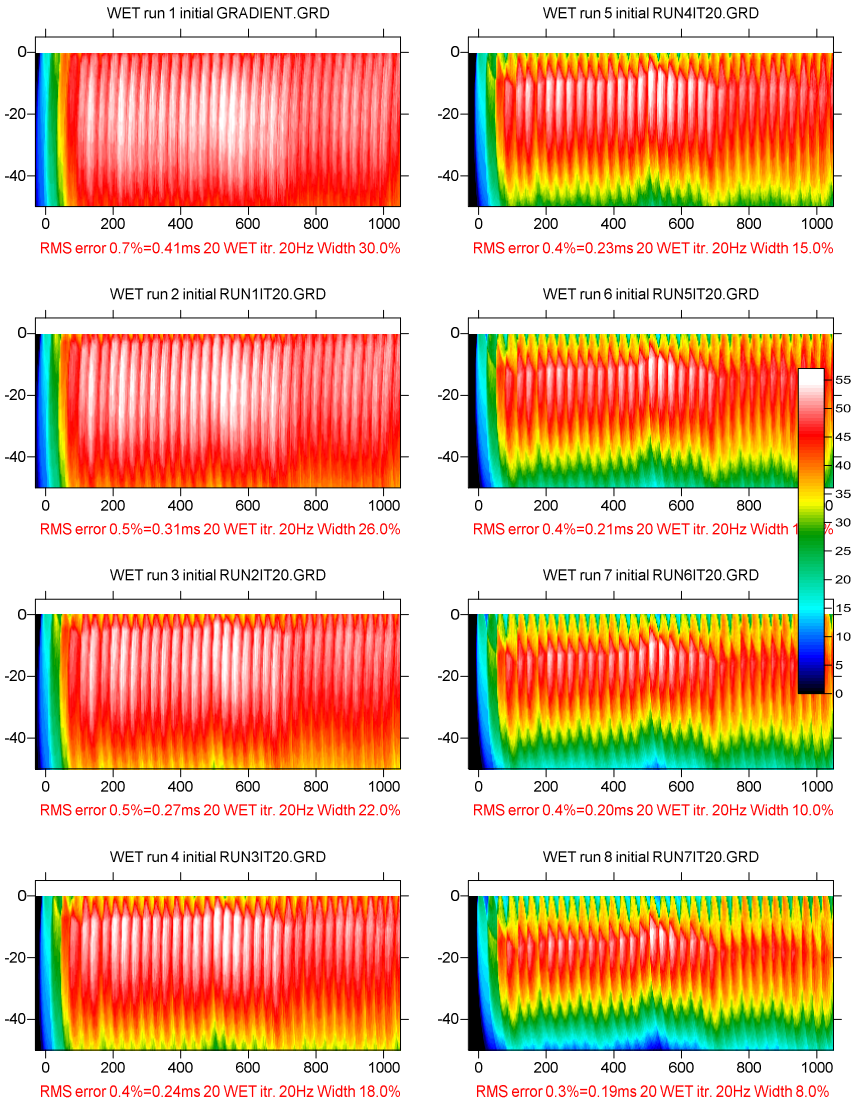


Fig. 2 : WET wavepath coverage plots obtained with Fig. 1. Unit is wavepaths per grid cell.

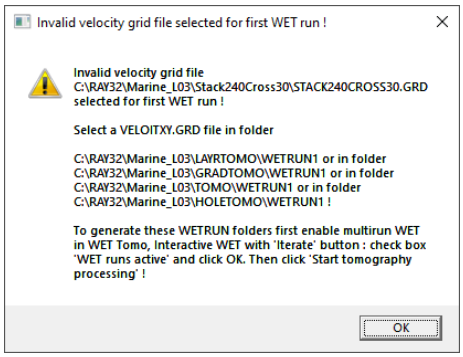


Fig. 3 : error prompt when you select a VELOITXY.GRD file not located in ..\WETRUN1 folder with our ***Grid|Plot multiple WET runs on one page*** command available with our 5.02 Pro version.

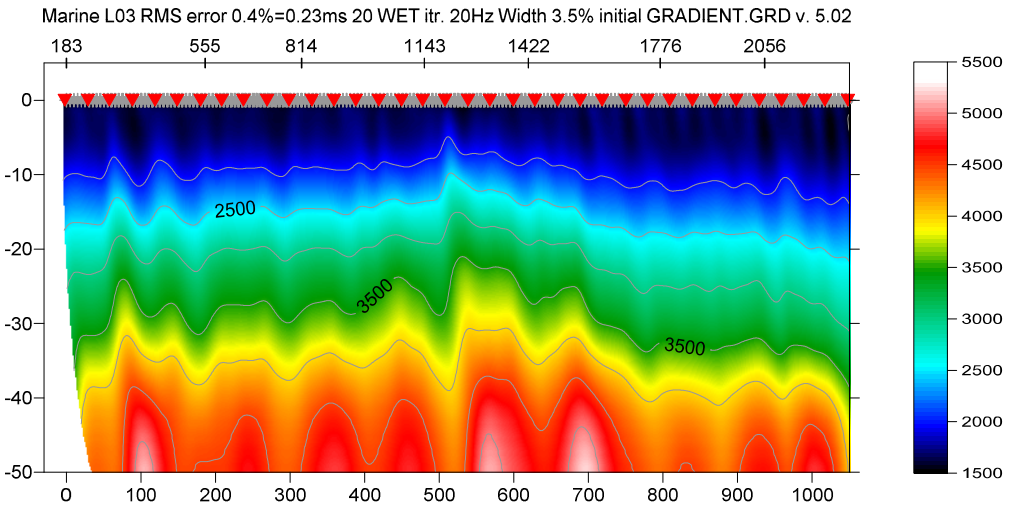


Fig. 4 : 20 Steepest-Descent WET iterations using 1D-gradient starting model (Fig. 6). Discard WET smoothing (Fig. 14). Manual WET smoothing filter : half-width 15 columns, half-height 15 rows. Gaussian Smoothing filter weighting : ***Used width of Gaussian*** set to 1.5SD. ***Grid cell size*** forced to 0.5m in *Header, Profile* (Fig. 11). Starting model shown in Fig. 6. Fig. 10 shows misfit for one shot gather and for shot-sorted traveltime curves.

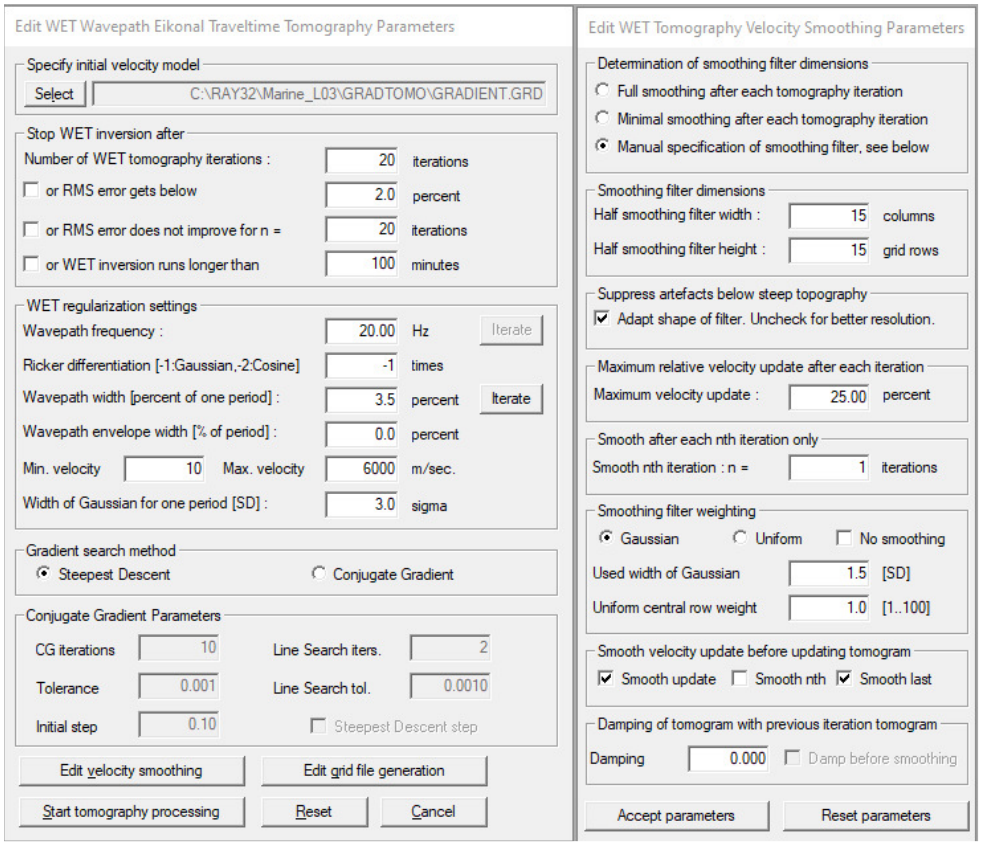


Fig. 5 : WET Tomo, Interactive WET settings for Fig. 4. ***Wavepath frequency*** lowered to 20Hz from default 50Hz for this long line. Manual WET smoothing filter : half-width 15 columns, half-height 15 rows. Gaussian Smoothing filter weighting : ***Used width of Gaussian*** set to 1.5SD. ***Ricker differentiation*** left at default setting of -1 [Gaussian] for ***Gaussian WET update weighting*** across each WET wavepath. Compare with Fig. 21 settings.

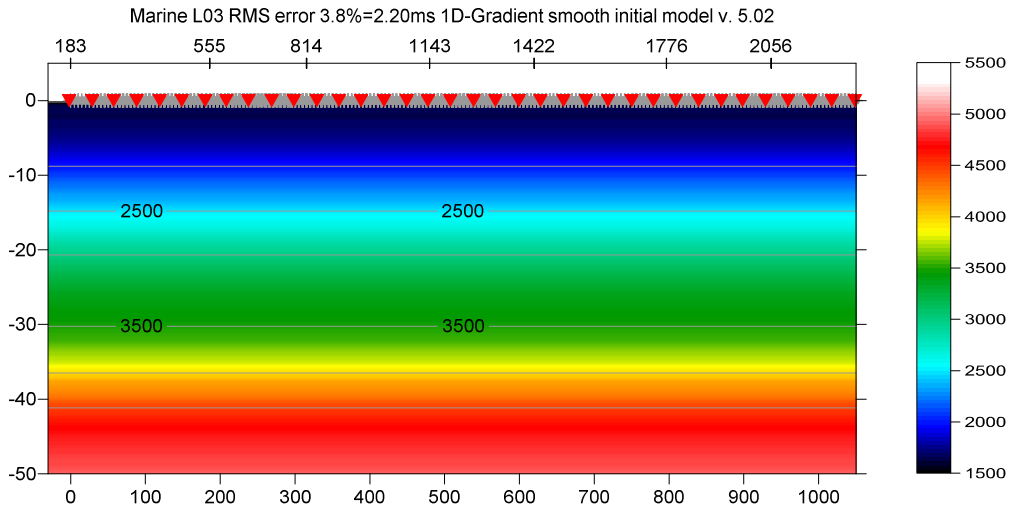


Fig. 6 : select ***Smooth invert, WET with 1D-gradient initial model*** to obtain this laterally averaged DeltatV starting model (Sheehan 2005) for Fig. 4. Also used as starting model for Fig. 1 multirun WET inversion described on page 10 / with settings shown in Fig. 21 and 22.

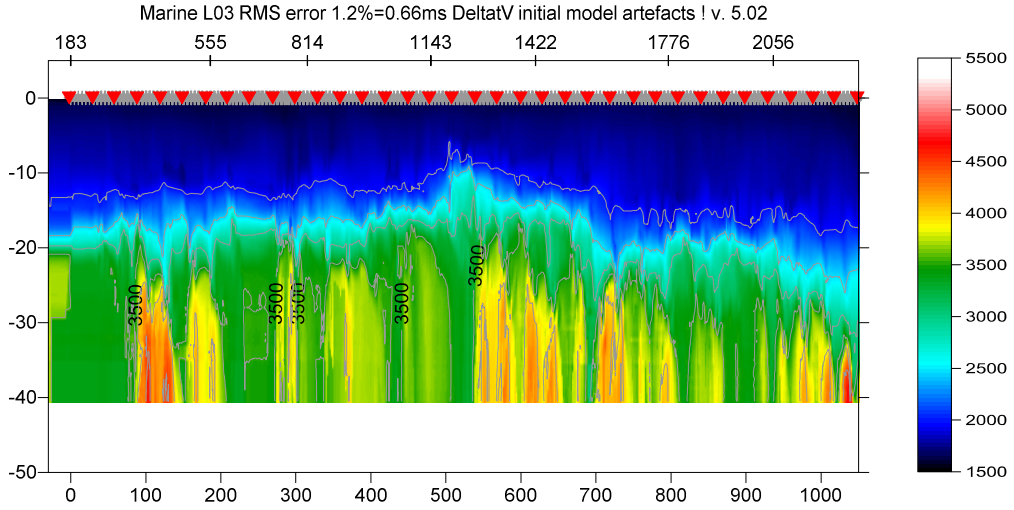
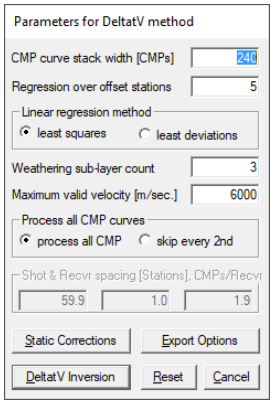
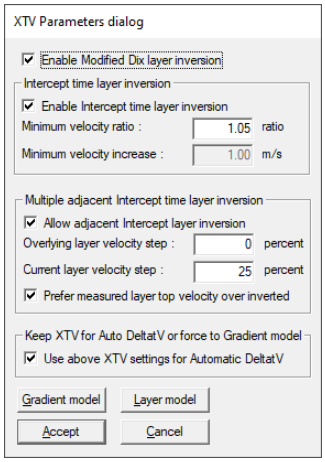


Fig. 7 : alternative interactive DeltatV+layered XTV starting model. See Fig. 8 and Fig. 9 for DeltatV and XTV settings.





Left : Fig. 8 : *DeltatV, Interactive DeltatV* for Fig. 7.

Right : Fig. 9 : *DeltatV, XTV parameters for constant-velocity layers* for Fig. 7.

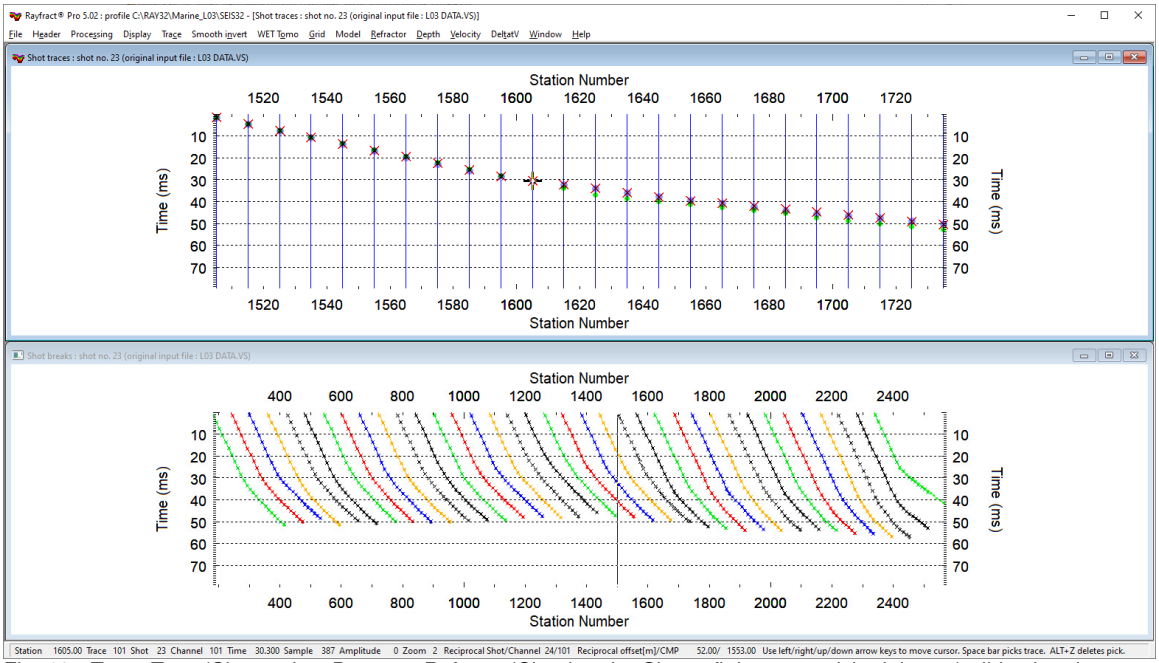


Fig. 10 : Top : *Trace|Shot gather*. Bottom : *Refractor|Shot breaks*. Shows fit between picked times (solid colored curves, red crosses) and modeled times (dashed colored curves, blue dots) for Fig. 4 WET tomogram. Green dots are your reciprocal picks.

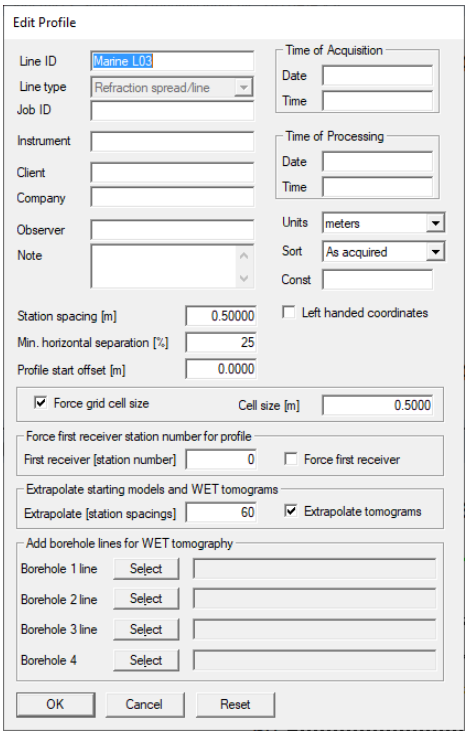


Fig. 11 (left) : *Header|Profile* . Set ***Station spacing*** to 0.5m. Check ***Force grid cell size***. Set ***Cell size*** to 0.5m. Check ***Extrapolate tomograms***. Set ***Extrapolate [station spacings]*** to 60. Click OK. Before importing the Geometrics Plotrefa .VS uncheck ***File, Import data Settings, Adjust profile station spacing***. See Fig. 12 below.

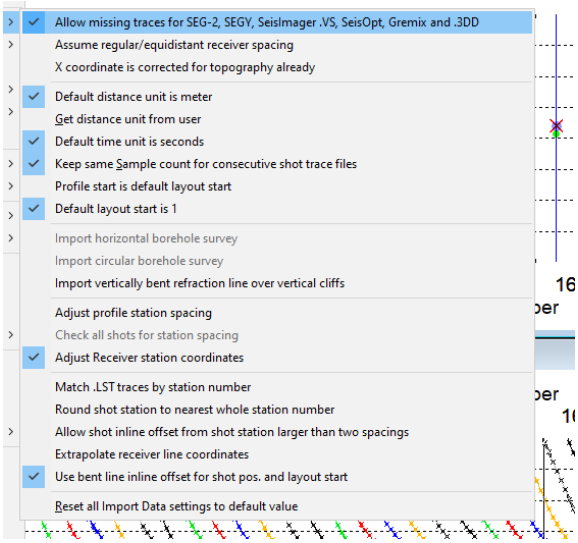


Fig. 12 (right): *File, Import data Settings*. Uncheck option ***Adjust profile station spacing*** before importing the Geometrics Plotrefa .VS file via *File|Import Data* dialog as shown in Fig. 13.

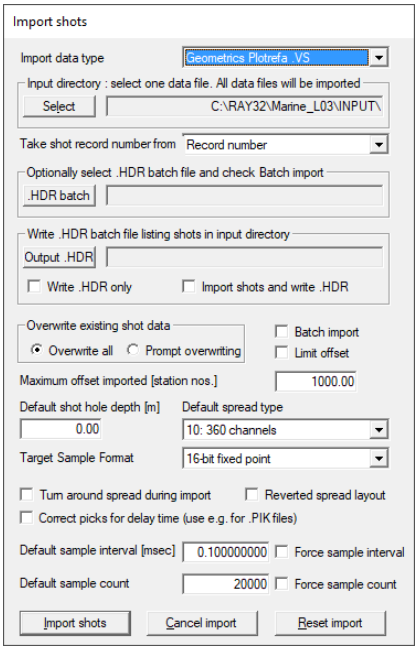


Fig. 13 (left) : *File, Import Data*. Set ***Import data type*** to Geometrics Plotrefa .VS. Click ***Select*** button and select file **`L03 Data.VS`** in your ..\INPUT folder. Leave ***Default spread type*** at 10: 360 channels. Edit as shown and click button ***Import Shots***.

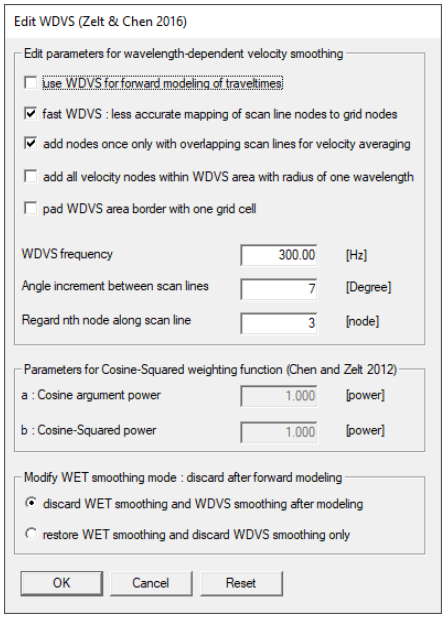


Fig. 14 (right) : *Model, WDVS Smoothing*. Click radio button ***discard WET smoothing and WDVS smoothing after modeling*** and click OK.

<u>To create the profile database, import the data and browse the imported shots do these steps :</u>

- ***File\New Profile***…, set *File name* to **`MARINE_L03`** and click *Save button*
- in the prompt shown next (Fig. 15) click ***No*** button to determine ***Profile start*** / first receiver station number by dividing the first receiver position in the .VS file by our *Station spacing* (Fig. 11)
- in ***Header\Profile***… select *Line type* **`Refraction spread/line`** . Set *Station spacing* to 0.5 m (Fig. 11).
- in ***Header\Profile***… check box *Force grid cell size* and set field *Cell size [m]* to 0.5m (Fig. 11)
- check box ***Extrapolate tomograms*** and set field ***Extrapolate [station spacings]*** to 60. See Fig. 11.
- download archive https://rayfract.com/tutorials/Marine_L03.zip . Open Windows Explorer and copy Marine_L03.zip into folder **`C:\RAY32\MARINE_L03\INPUT`**. Unzip here to obtain the **`L03 Data.VS`** .
- uncheck option ***File\Import Data Settings\Adjust profile station spacing.*** See Fig. 12.
- select ***File\Import Data***… and set *Import data type* to **`Geometrics Plotrefa .VS`**. See Fig. 13.
- click ***Select*** *button* and navigate into **`C:\RAY32\MARINE_L03\INPUT`**
- select file **`L03 Data.VS`** & click *Open*
- leave *Default spread type* at **`10: 360 channels`**
- click ***Import shots button*** . When/if prompted to update the profile *station spacing* click ***No*** button.
- in our ***Import shot*** dialog leave ***Layout start [station no.]*** and ***Shot pos. [station no.]*** as displayed for each shot. Just click *Read button* to import the shot. Click *Read* button repeatedly to import all 37 shots displayed.
- select *Trace\Shot gather* to obtain Fig. 10
- click on title bar of *Refractor\Shot breaks* window (Fig. 10 bottom) and press ALT+P. Edit *Maximum time* to 80 ms & press ENTER key to redisplay. Repeat these steps for *Trace\Shot gather* window (Fig. 10 top).
- browse shots in *Trace\Shot gather* window with F7/F8 (Fig. 10 top)
- select *Processing menu* item ***Remove trigger jitter for all shots***

- edit ***DeltatV\DeltatV Static corrections*** dialog (Fig. 16) : increase ***Basement crossover*** from 10 to 30 stations. Check box ***Keep above settings for Automatic DeltatV***. Click button *Accept*. These steps are required to enable our *Smooth invert* and *DeltatV inversion* to work for this profile.

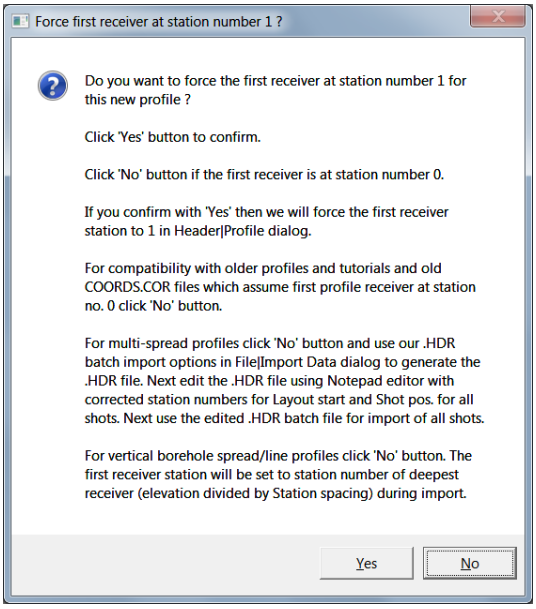


Fig. 15 : click *No* button to determine the first receiver station number for this profile from the Geometrics Plotrefa .VS by dividing the first receiver position in the .VS file by our ***Header|Profile|Station spacing*** (Fig. 11).

For compatibility with older profiles and tutorials and old COORDS.COR files which assume first profile receiver at station no. 0 click No button. For multi-spread profiles click No button and use our .HDR batch import options in *File|Import Data* dialog to generate the .HDR file. Next edit the .HDR file using MS Notepad editor with corrected station numbers for *Layout start* and *Shot pos.* for all shots. Next use the edited .HDR batch file for import of all shots.

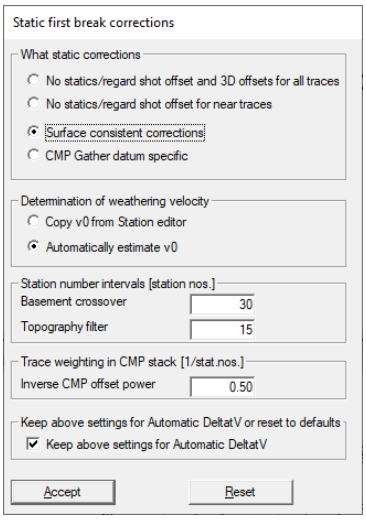


Fig. 16 : ***DeltatV, DeltatV Static corrections*** dialog. Increase ***Basement crossover*** from default 10 stations to 30 stations. Check box ***Keep above settings for Automatic DeltatV***. Click *Accept* button.

<u>Run default fail-safe Smooth inversion with 1D-gradient laterally averaged starting model :</u>

- check option *Grid|Receiver station ticks on top axis*
- check option *Grid|CS_CENTERED font for shot points and receivers* to fix Surfer 11 symbol display.
- edit *Grid|Surfer plot Limits* as in Fig. 19
- select *Model|WDVS Smoothing*. Click *discard WET smoothing and WDVS smoothing after modeling.*
- leave *use WDVS for forward modeling of traveltimes* unchecked (Fig. 14)
- uncheck blanking option *WET Tomo|Blank|Blank below envelope after last iteration*
- select ***Smooth invert|WET with 1D-gradient initial model***
- dismiss prompt *Shot point spacing is much too wide* (Fig. 20). This prompt is not relevant for marine refraction recorded at continuous incremental positions with towed streamer and short *Station spacing*.
- wait for the 1D-gradient starting model to display as in Fig. 6
- confirm prompt to continue with WET inversion to obtain WET output as shown below in Fig. 17

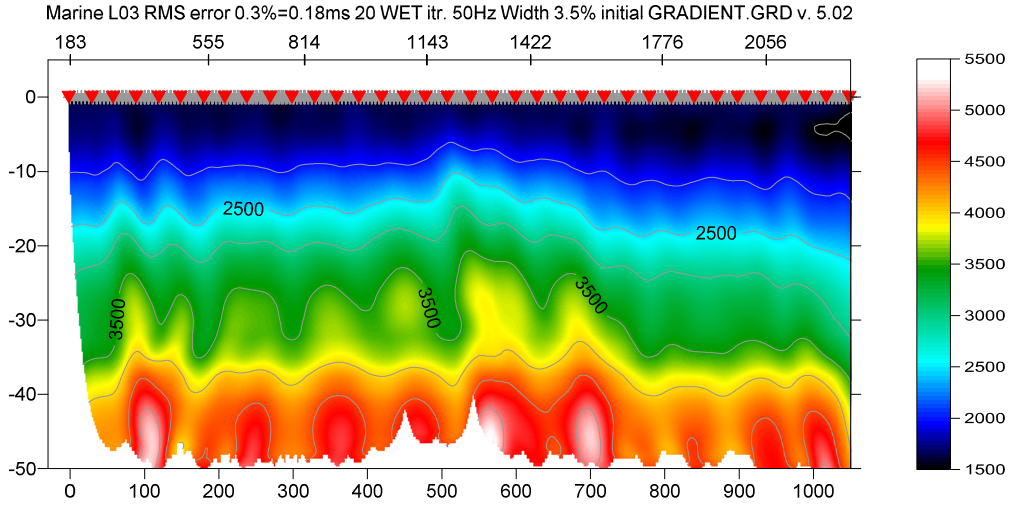


Fig. 17 : *Smooth invert|WET with 1D-gradient initial model*. ***Discard WET smoothing*** in ***Model|WDVS Smoothing*** dialog (Fig 14). Default WET smoothing. ***Grid cell size*** forced to 0.5m in *Header, Profile* (Fig. 11). Starting model shown in Fig. 6.

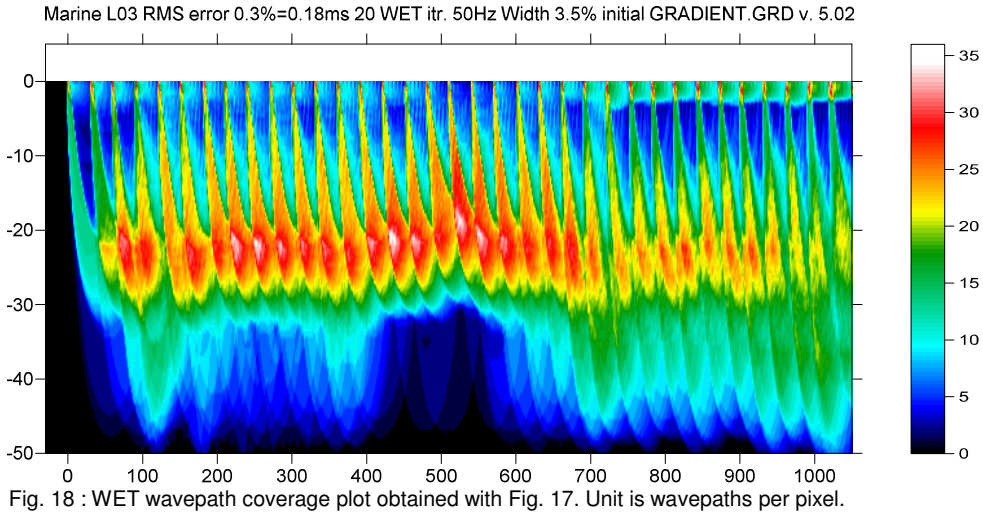


Fig. 18 : WET wavepath coverage plot obtained with Fig. 17. Unit is wavepaths per pixel.

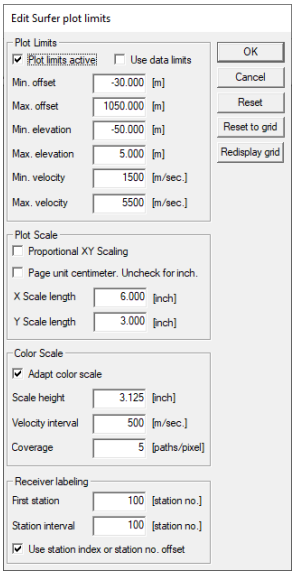


Fig. 19 (left) : *Grid|Surfer plot Limits* . Edit as shown and click OK .

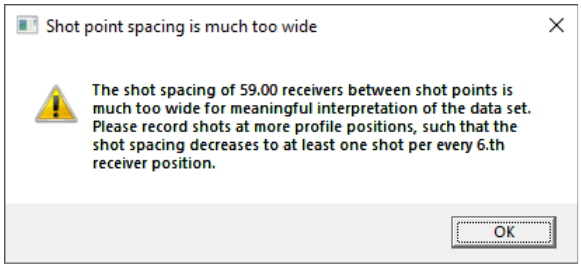


Fig. 20 (above) : warning prompt shown during *Smooth invert|WET with 1D-gradient initial model*. This prompt is not relevant for marine refraction data recorded at continuous incremental positions with towed streamer and short *Station spacing*.

Run interactive WET using default 1D-gradient starting model and manual WET smoothing :

Next we try to vary and improve the WET smoothing filter to minimize lateral positioning errors of velocity anomalies at the bottom of the tomogram. These positioning errors are due to the fact that marine refraction shots have been recorded by streamer in one direction only (Fig. 10 bottom) :

- select *WET Tomo|Interactive WET tomography*
- dismiss again the warning prompt shown in Fig. 20
- edit WET main dialog as in Fig. 5 (left). Lower WET ***Wavepath frequency*** to 20Hz for this long line.
- click button *Iterate*. Uncheck box *WET runs active*. Click button OK.
- click button *Edit velocity smoothing*. Edit as in Fig. 5 (right).
- click button ***Manual specification of smoothing filter***
- set ***Half smoothing filter width*** to 15 columns
- set ***Half smoothing filter height*** to 15 rows
- in frame *Smoothing filter weighting* click radio button ***Gaussian***
- set ***Used width of Gaussian*** to 1.5 SD (Standard Deviations)
- click buttons *Accept parameters* and *Start tomography processing*
- obtain the WET tomogram shown in Fig. 4
- visually compare Fig. 4 with Fig. 17
- at inline offset 500 m the basement fault is more vertical in Fig. 4 than in Fig. 17
- at inline offset 1000 m the high-velocity anomaly at the bottom of the tomogram is moved to the left in Fig. 4 compared to Fig. 17

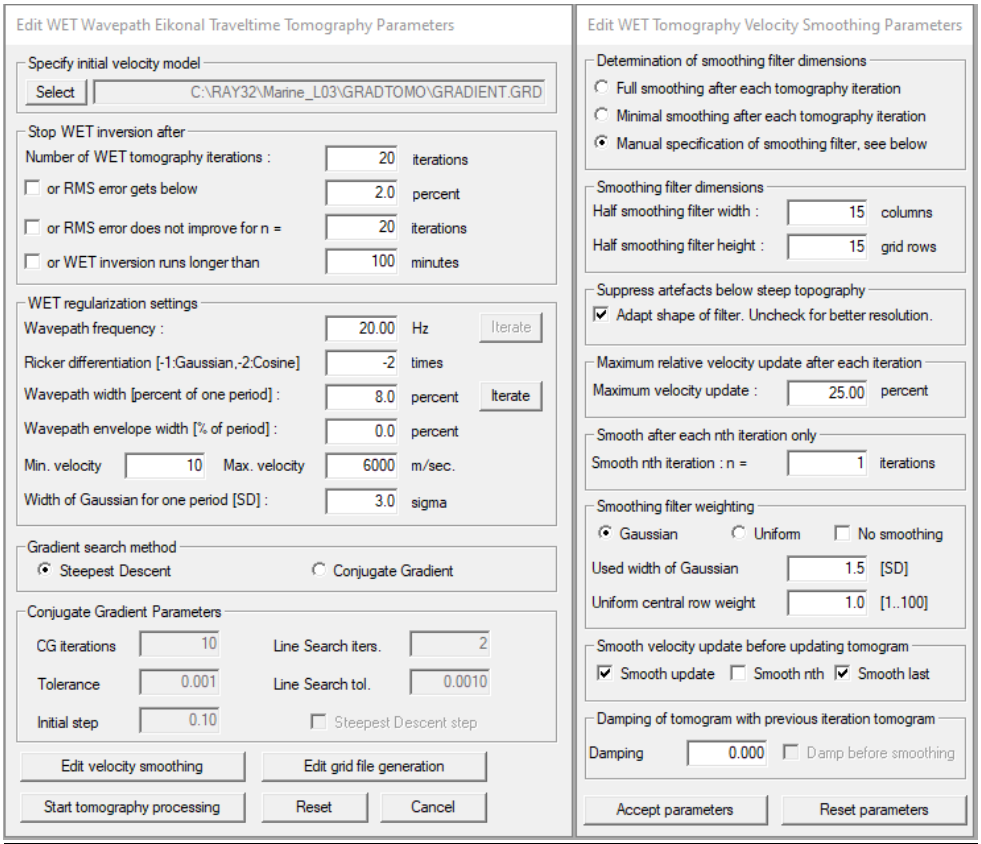


Fig. 21 : WET Tomo, Interactive WET settings for Fig. 1. ***Wavepath frequency*** lowered to 20Hz from default 50Hz for this long line. ***Ricker differentiation*** set to -2 : use ***Cosine-Squared WET wavepath update weighting*** for better lateral resolution in the basement. Manual WET smoothing filter : half-width 15 columns, half-height 15 rows. Gaussian Smoothing filter weighting : ***Used width of Gaussian*** set to 1.5SD.

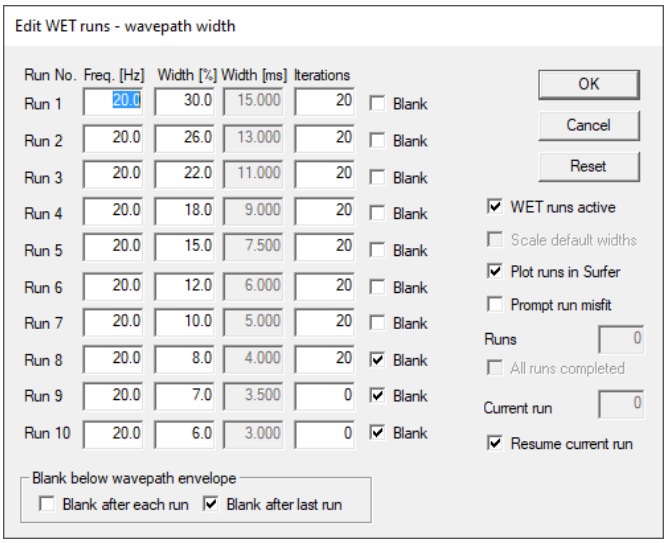


Fig. 22 : ***WET Tomo, Interactive WET, Iterate*** dialog settings used for Fig. 1. Edit WET runs as shown. Click button *Reset* to lower the frequency to 20Hz for all WET runs. Check box ***WET runs active***. Click button OK to confirm.

Multiscale WET using default 1D-gradient starting model and manual WET smoothing :

- select *WET Tomo|Interactive WET tomography*
- dismiss again the warning prompt shown in Fig. 20
- edit WET main dialog as in Fig. 21 (left). Lower WET ***Wavepath frequency*** to 20Hz for this long line.
- change ***Ricker differentiation*** from default -1 to -2 for ***Cosine-Squared WET update weighting*** across WET wavepaths for better lateral resolution in the basement
- click button *Edit velocity smoothing*. Edit as in Fig. 21 (right).
- click button ***Manual specification of smoothing filter***
- set ***Half smoothing filter width*** to 15 columns
- set ***Half smoothing filter height*** to 15 rows
- in frame *Smoothing filter weighting* click radio button ***Gaussian***
- set ***Used width of Gaussian*** to 1.5 SD (Standard Deviations) and click button *Accept parameters*
- click button *Iterate*. Click button *Reset* to lower the frequency to 20Hz for all WET runs. See Fig. 22.
- check box *WET runs active*. Click button OK.
- click button *Start tomography processing* to obtain the 8 WET run tomograms shown in Fig. 1
- visually compare the last WET run shown at bottom-right of Fig. 1 with Fig. 4
- Fig. 1 shows better lateral resolution in the final WET run at bottom right. Also the RMS error of 0.19ms is lower than the RMS error of 0.23ms shown in Fig. 4.
- in our 5.02 Pro version select ***Grid\Plot multiple WET runs on one page*** and velocity grid file `C:\RAY32\MARINE_L03\GRADTOMO\WETRUN1\VELOIT20.GRD` to obtain the multirun WET plot shown in Fig. 1 and the multirun coverage plot shown in Fig. 2

Here is the DropBox .RAR archive link for this MARINE_LO3 profile folder :

https://www.dropbox.com/scl/fi/wd4qryigea8qoi9tiarir/Marine_L03_Oct24_25.rar?rlkey=kdv1ced2uwoem02bb9843yacq&st=mtddxr49&dl=0

References

Hiltunen, D. R., Hudyma, N., Quigley, T. P., & Samakur, C. 2007. Ground Proving Three Seismic Refraction Tomography Programs. Transportation Research Record, 2016(1), 110–120. https://doi.org/10.3141/2016-12
https://www.researchgate.net/publication/242072938 .

Rohdewald, S.R.C. 2021a. Improving the resolution of Fresnel volume tomography with wavelength-dependent velocity smoothing, Symposium on the Application of Geophysics to Engineering and Environmental Problems Proceedings : 305-308. https://doi.org/10.4133/sageep.33-169 . Slides at https://rayfract.com/pub/SAGEEP%202021%20slides.pdf

Rohdewald, S.R.C. 2021b. Improved interpretation of SAGEEP 2011 blind refraction data using Frequency-Dependent Traveltime Tomography, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-4214, https://doi.org/10.5194/egusphere-egu21-4214

Schuster, Gerard T. and Quintus-Bosz, Aksel 1993. Wavepath eikonal traveltime inversion : Theory. Geophysics, volume 58, pp. 1314-1323. https://dx.doi.org/10.1190/1.1443514

Sheehan J.R., Doll W.E. and Mandell W.A. 2005a. An Evaluation of Methods and Available Software for Seismic Refraction Tomography. Journal of Environmental and Engineering Geophysics, volume 10, pp. 21-34. ISSN 1083-1363, Environmental and Engineering Geophysical Society. JEEG March 2005 issue. https://dx.doi.org/10.2113/JEEG10.1.21 . https://rayfract.com/srt_evaluation.pdf
https://www.researchgate.net/publication/242159023

Watanabe Toshiki et al. 1999. Seismic traveltime tomography using Fresnel volume approach. SEG Houston 1999 Meeting, Expanded Abstracts. https://www.researchgate.net/publication/240735641 .
https://dx.doi.org/10.1190/1.1820777

Zelt, C. A. and J. Chen 2016. Frequency-dependent traveltime tomography for near-surface seismic refraction data, Geophys. J. Int., 207, 72-88, 2016. See https://dx.doi.org/10.1093/gji/ggw269 and https://www.researchgate.net/publication/305487180 .

Zelt, C.A., Haines, S., Powers, M.H. et al. 2013. Blind Test of Methods for Obtaining 2-D Near-Surface Seismic Velocity Models from First-Arrival Traveltimes, JEEG, Volume 18(3), 183-194. https://www.researchgate.net/publication/267026965