

Plot first 8 WET runs for MARINE L03 Steepest-Descent multiscale WET on one page with latest 5.02 Pro / Oct 2025 :

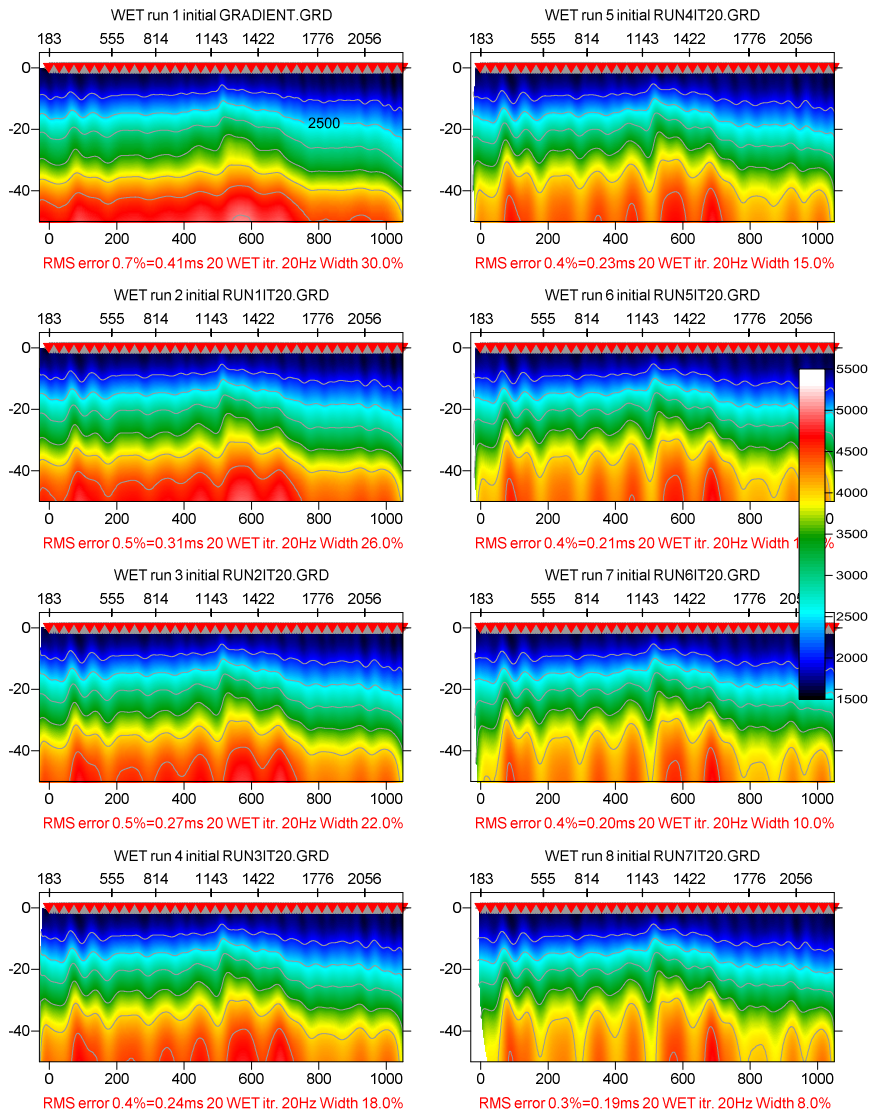


Fig. 1 : plot first 8 Steepest-Descent WET runs (20 WET iterations per run) for profile MARINE_L03 multiscale WET on one page with new Grid menu command **Plot multiple WET runs on one page** available with our 5.02 Pro version. The laterally averaged 1D-gradient starting model for first WET run is shown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

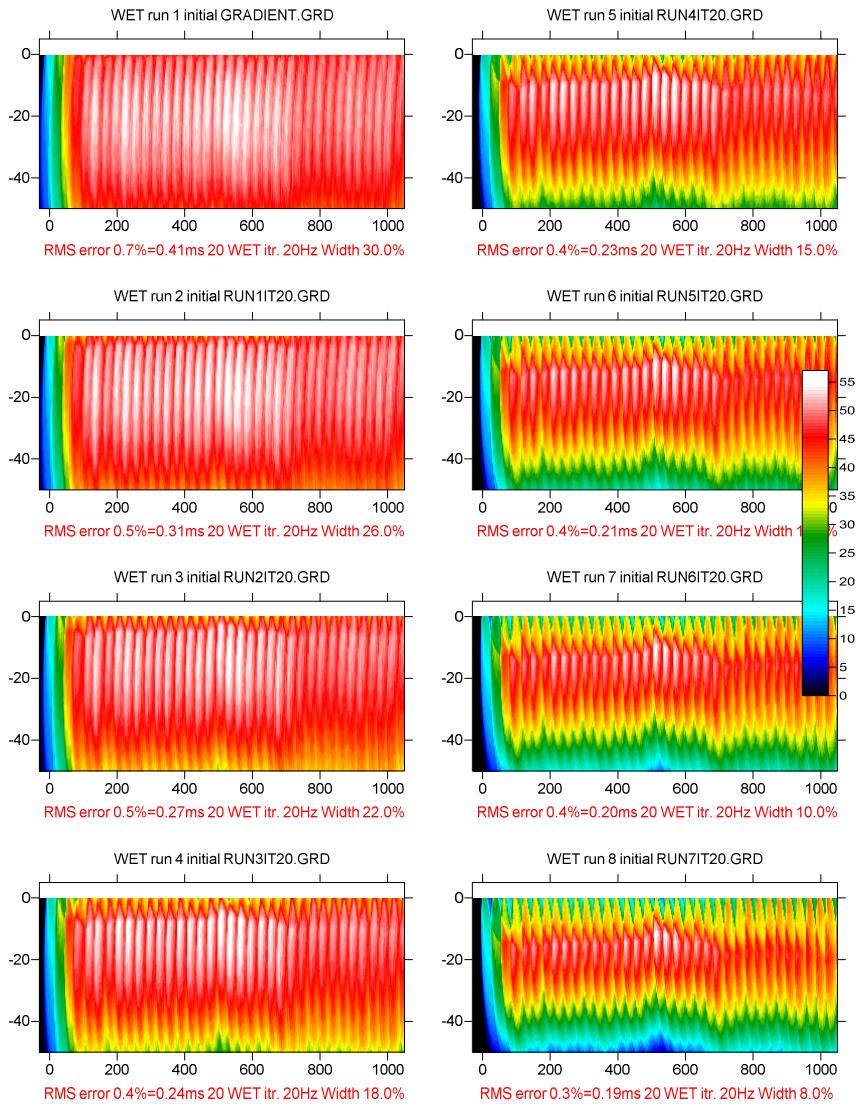


Fig. 2 : WET wavepath coverage plots obtained with Fig. 1. Unit is wavepaths per grid cell.

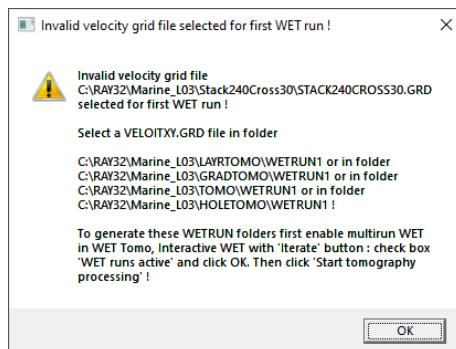


Fig. 3 : error prompt when you select a VELOITXY.GRD file not located in ..WETRUN1 folder with our **Grid/Plot multiple WET runs on one page** command available with our 5.02 Pro version.

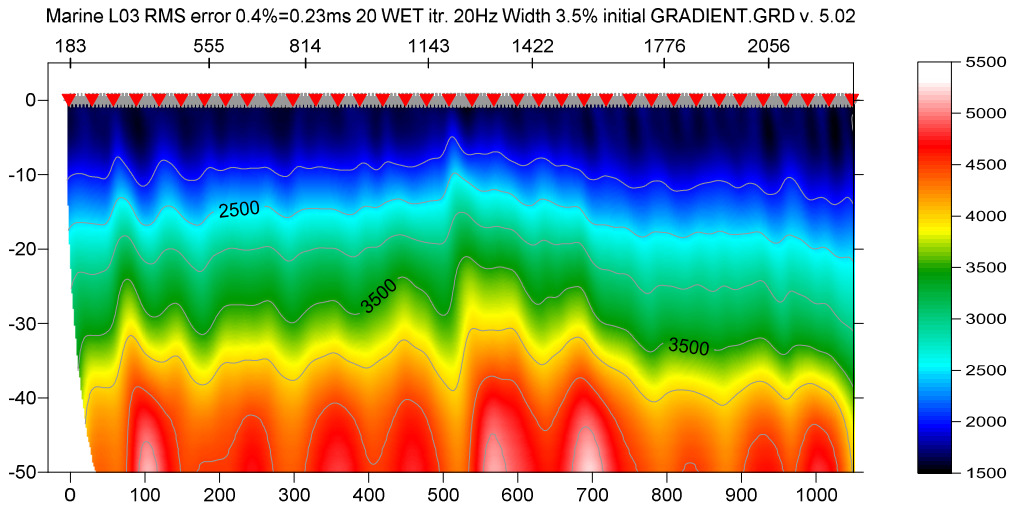


Fig. 4 : 20 Steepest-Descent WET iterations using 1D-gradient starting model (Fig. 6). Discard WET smoothing (Fig. 14). Manual WET smoothing filter : half-width 15 columns, half-height 15 rows. Gaussian Smoothing filter weighting : **Used width of Gaussian** set to 1.5SD. **Grid cell size** forced to 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 traveltimes curves.

Edit WET Wavepath Eikonal Traveltime Tomography Parameters

Specify initial velocity model
Select C:\RAY32\Marine_L03\GRADTOMO\GRADIENT.GRD

Stop WET inversion after
Number of WET tomography iterations : 20 iterations
☐ or RMS error gets below 2.0 percent
☐ or RMS error does not improve for n = 20 iterations
☐ or WET inversion runs longer than 100 minutes

WET regularization settings
Wavepath frequency : 20.00 Hz Iterate
Ricker differentiation [-1:Gaussian,-2:Cosine] -1 times
Wavepath width [percent of one period] : 3.5 percent Iterate
Wavepath envelope width [% of period] : 0.0 percent
Min. velocity 10 Max. velocity 6000 m/sec.
Width of Gaussian for one period [SD] : 3.0 sigma

Gradient search method
☒ Steepest Descent ☐ Conjugate Gradient

Conjugate Gradient Parameters
CG iterations 10 Line Search iters. 2
Tolerance 0.001 Line Search tol. 0.0010
Initial step 0.10 ☐ Steepest Descent step

Edit velocity smoothing Edit grid file generation
Start tomography processing Reset Cancel

Edit WET Tomography Velocity Smoothing Parameters

Determination of smoothing filter dimensions
☐ Full smoothing after each tomography iteration
☐ Minimal smoothing after each tomography iteration
☒ Manual specification of smoothing filter, see below

Smoothing filter dimensions
Half smoothing filter width : 15 columns
Half smoothing filter height : 15 grid rows

Suppress artefacts below steep topography
☒ Adapt shape of filter. Uncheck for better resolution.

Maximum relative velocity update after each iteration
Maximum velocity update : 25.00 percent

Smooth after each nth iteration only
Smooth nth iteration : n = 1 iterations

Smoothing filter weighting
☒ Gaussian ☐ Uniform ☐ No smoothing
Used width of Gaussian 1.5 [SD]
Uniform central row weight 1.0 [1..100]

Smooth velocity update before updating tomogram
☒ Smooth update ☐ Smooth nth ☒ Smooth last

Damping of tomogram with previous iteration tomogram
Damping 0.000 ☐ Damp before smoothing

Accept parameters Reset parameters

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.

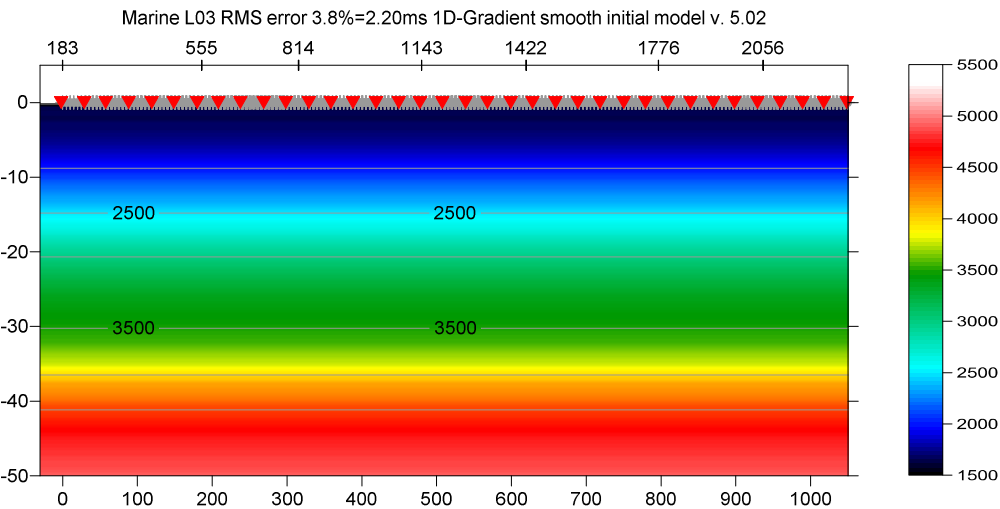


Fig. 6 : select **Smooth invert, WET with 1D-gradient initial model** to obtain this laterally averaged DeltatV starting model (Sheehan 2005) for Fig. 4. Also used as starting model for Fig. 1 multirun WET inversion described on page 10 / with settings shown in Fig. 21 and 22.

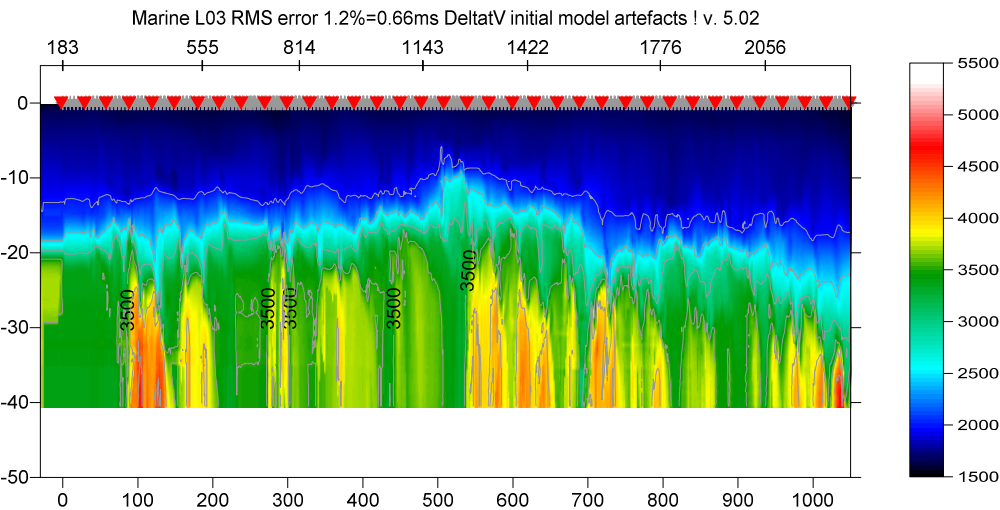
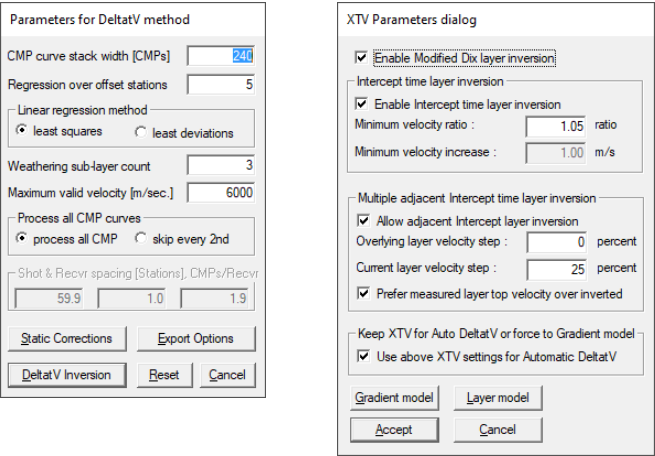


Fig. 7 : alternative interactive DeltatV+layered XTV starting model. See Fig. 8 and Fig. 9 for DeltatV and XTV settings.



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

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

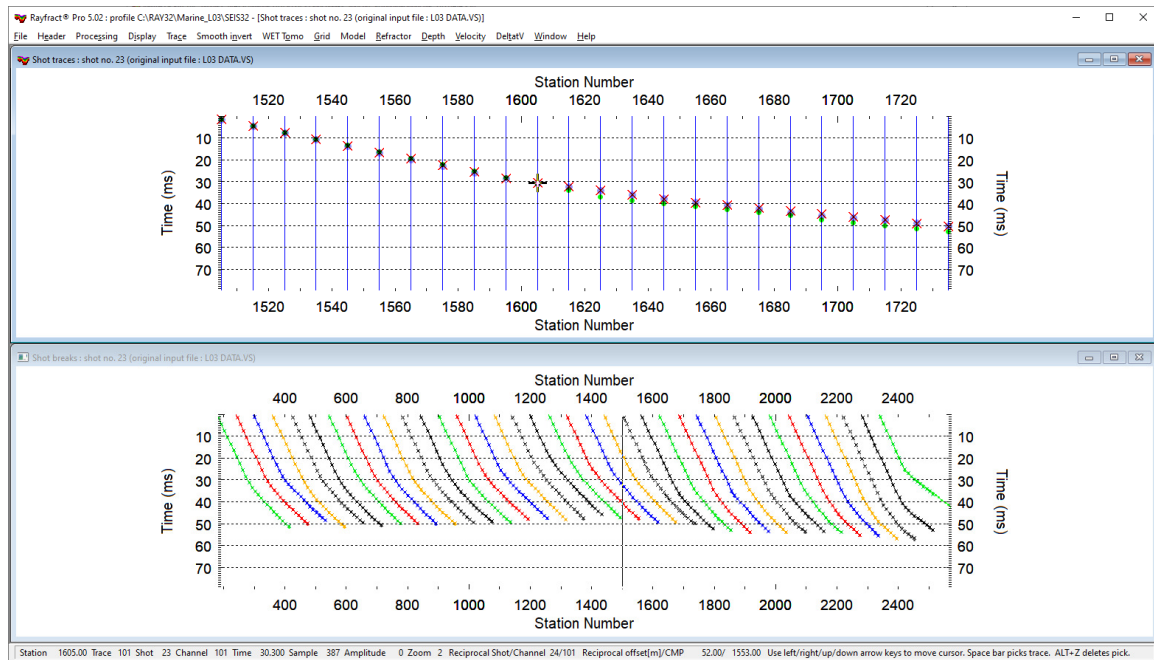


Fig. 10 : Top : *Trace/Shot gather*. Bottom : *Refractor/Shot breaks*. Shows fit between picked times (solid colored curves, red crosses) and modeled times (dashed colored curves, blue dots) for Fig. 4 WET tomogram. Green dots are your reciprocal picks.

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.

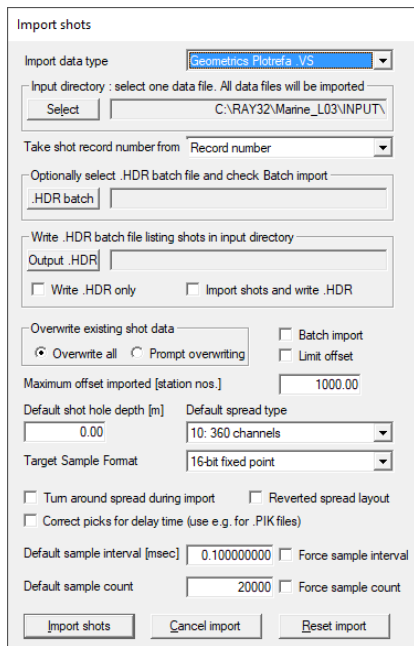


Fig. 13 (left) : *File, Import Data*. Set **Import data type** to Geometrics Plotrefa .VS. Click **Select** button and select file **L03 Data.VS** in your **..\INPUT** folder. Leave **Default spread type** at 10: 360 channels. Edit as shown and click button **Import Shots**.

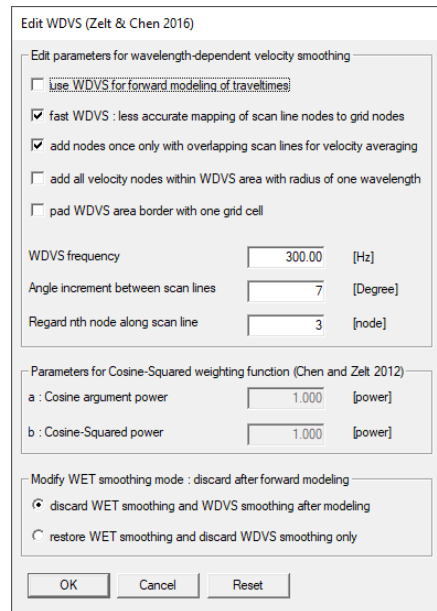


Fig. 14 (right) : *Model, WDVS Smoothing*. Click radio button **discard WET smoothing and WDVS smoothing after modeling** and click OK.

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

- **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.

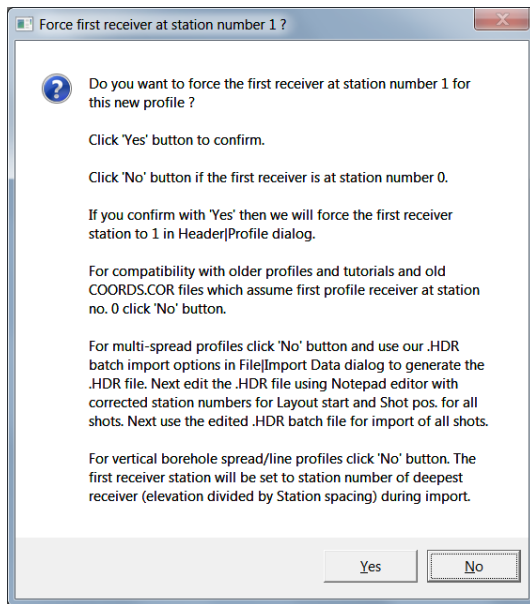


Fig. 15 : click *No* button to determine the first receiver station number for this profile from the Geometrics Plotrefa .VS by dividing the first receiver position in the .VS file by our **Header/Profile/Station spacing** (Fig. 11).

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.

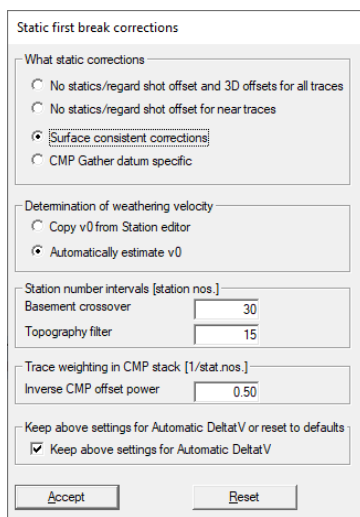


Fig. 16 : **DeltatV, DeltatV Static corrections** dialog. Increase **Basement crossover** from default 10 stations to 30 stations. Check box **Keep above settings for Automatic DeltatV**. Click *Accept* button.

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

- 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

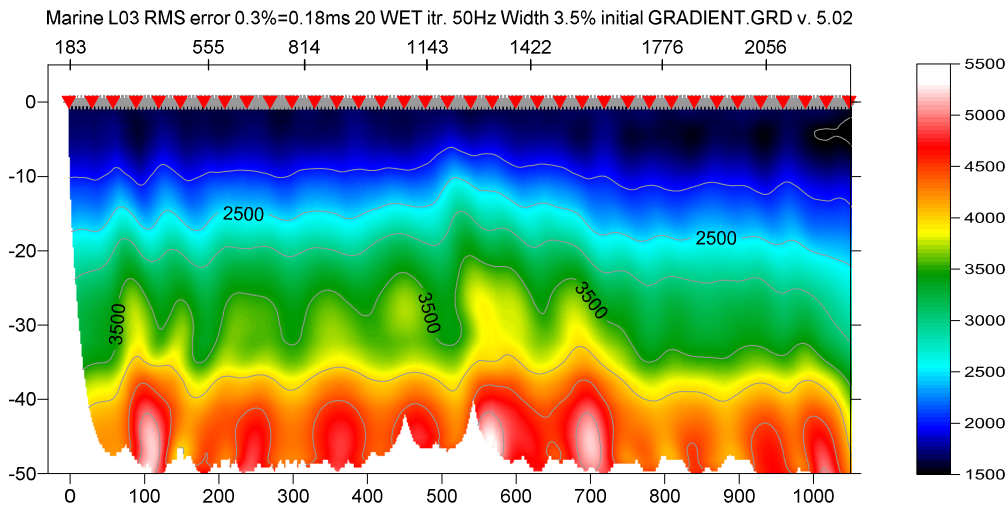


Fig. 17 : *Smooth invert|WET with 1D-gradient initial model. Discard WET smoothing in Model|WDVS Smoothing dialog (Fig 14). Default WET smoothing. Grid cell size forced to 0.5m in Header, Profile (Fig. 11). Starting model shown in Fig. 6.*

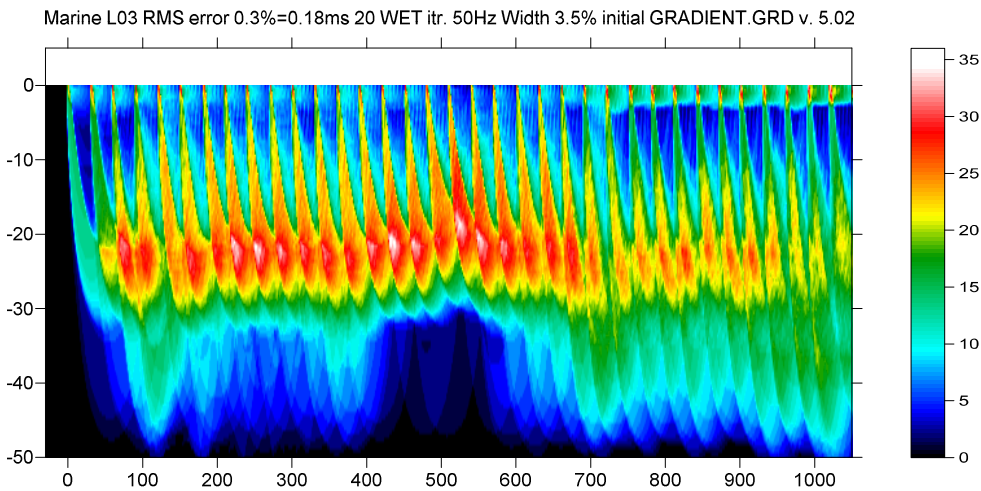


Fig. 18 : WET wavepath coverage plot obtained with Fig. 17. Unit is wavepaths per pixel.

Edit Surfer plot limits

Plot Limits

☒ Plot limits active ☐ Use data limits

Min. offset -30.000 [m]

Max. offset 1050.000 [m]

Min. elevation -50.000 [m]

Max. elevation 5.000 [m]

Min. velocity 1500 [m/sec.]

Max. velocity 5500 [m/sec.]

Plot Scale

☐ Proportional XY Scaling

☐ Page unit centimeter. Uncheck for inch.

X Scale length 6.000 [inch]

Y Scale length 3.000 [inch]

Color Scale

☒ Adapt color scale

Scale height 3.125 [inch]

Velocity interval 500 [m/sec.]

Coverage 5 [paths/pixel]

Receiver labeling

First station 100 [station no.]

Station interval 100 [station no.]

☒ Use station index or station no. offset

OK

Cancel

Reset

Reset to grid

Redisplay grid

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

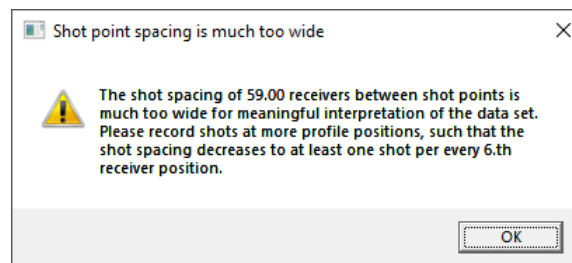


Fig. 20 (above) : warning prompt shown during *Smooth invert|WET with 1D-gradient initial model*. This prompt is not relevant for marine refraction data recorded at continuous incremental positions with towed streamer and short *Station spacing*.

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

The image shows two side-by-side dialog boxes from the WET software.

Left Dialog: Edit WET Wavepath Eikonal Traveltime Tomography Parameters

- Specify initial velocity model:** Select *C:\RAY32\Marine_L03\GRADTOMO\GRADIENT.GRD*
- Stop WET inversion after:**
 - Number of WET tomography iterations: 20 iterations
 - ☐ or RMS error gets below 2.0 percent
 - ☐ or RMS error does not improve for n = 20 iterations
 - ☐ or WET inversion runs longer than 100 minutes
- WET regularization settings:**
 - Wavepath frequency: 20.00 Hz [Iterate]
 - Ricker differentiation [-1:Gaussian, -2:Cosine]: -2 times
 - Wavepath width [percent of one period]: 8.0 percent [Iterate]
 - Wavepath envelope width [% of period]: 0.0 percent
 - Min. velocity: 10 Max. velocity: 6000 m/sec.
 - Width of Gaussian for one period [SD]: 3.0 sigma
- Gradient search method:**
 - ☒ Steepest Descent ☐ Conjugate Gradient
- Conjugate Gradient Parameters:**
 - CG iterations: 10 Line Search iters.: 2
 - Tolerance: 0.001 Line Search tol.: 0.0010
 - Initial step: 0.10 ☐ Steepest Descent step
- Buttons: *Edit velocity smoothing*, *Edit grid file generation*, *Start tomography processing*, *Reset*, *Cancel*

Right Dialog: Edit WET Tomography Velocity Smoothing Parameters

- Determination of smoothing filter dimensions:**
 - ☐ Full smoothing after each tomography iteration
 - ☐ Minimal smoothing after each tomography iteration
 - ☒ Manual specification of smoothing filter, see below
- Smoothing filter dimensions:**
 - Half smoothing filter width: 15 columns
 - Half smoothing filter height: 15 grid rows
- Suppress artefacts below steep topography:**
 - ☒ Adapt shape of filter. Uncheck for better resolution.
- Maximum relative velocity update after each iteration:**
 - Maximum velocity update: 25.00 percent
- Smooth after each nth iteration only:**
 - Smooth nth iteration : n = 1 iterations
- Smoothing filter weighting:**
 - ☒ Gaussian ☐ Uniform ☐ No smoothing
 - Used width of Gaussian: 1.5 [SD]
 - Uniform central row weight: 1.0 [1..100]
- Smooth velocity update before updating tomogram:**
 - ☒ Smooth update ☐ Smooth nth ☒ Smooth last
- Damping of tomogram with previous iteration tomogram:**
 - Damping: 0.000 ☐ Damp before smoothing
- Buttons: *Accept parameters*, *Reset parameters*

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.

Edit WET runs - wavepath width

Run No.	Freq. [Hz]	Width [%]	Width [ms]	Iterations	
Run 1	20.0	30.0	15.000	20	☐ Blank
Run 2	20.0	26.0	13.000	20	☐ Blank
Run 3	20.0	22.0	11.000	20	☐ Blank
Run 4	20.0	18.0	9.000	20	☐ Blank
Run 5	20.0	15.0	7.500	20	☐ Blank
Run 6	20.0	12.0	6.000	20	☐ Blank
Run 7	20.0	10.0	5.000	20	☐ Blank
Run 8	20.0	8.0	4.000	20	☒ Blank
Run 9	20.0	7.0	3.500	0	☒ Blank
Run 10	20.0	6.0	3.000	0	☒ Blank

Blank below wavepath envelope
☐ Blank after each run ☒ Blank after last run

☒ WET runs active
☐ Scale default widths
☒ Plot runs in Surfer
☐ Prompt run misfit
Runs
☐ All runs completed
Current run
☒ Resume current run

OK Cancel Reset

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 **GridPlot 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

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