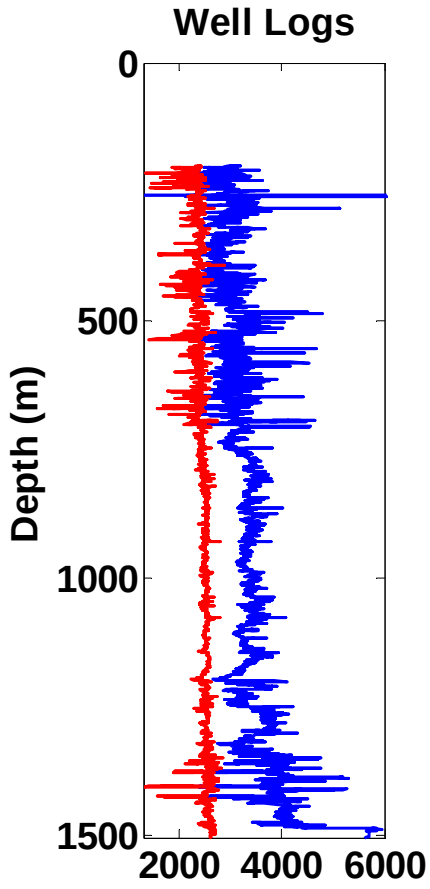
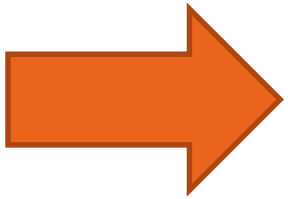
The Art of Well-Tying With New MATLAB Tools

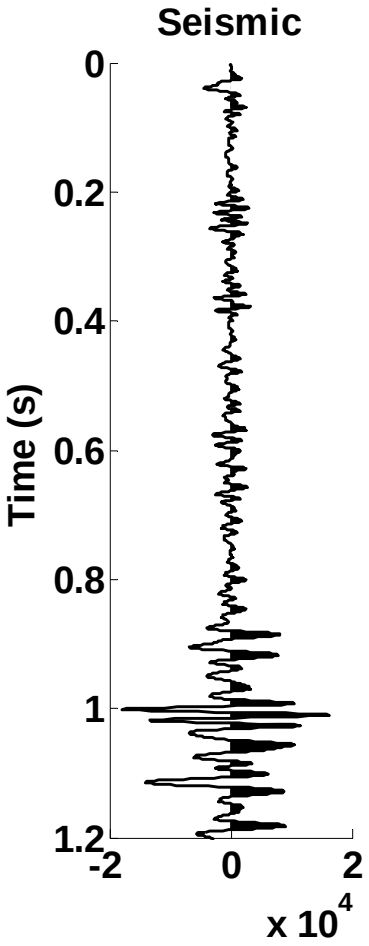
Heather J.E. Lloyd and Gary F. Margrave

Outline

- What are the steps of computing a well tie?
- Why do we do these steps?
- How can I do this in MATLAB?


Well Logs
Depth (m)
0
500
1000
1500
2000
4000
6000




Seismic
Time (s)
0
0.2
0.4
0.6
0.8
1
1.2
-2
0
2
x 10^4

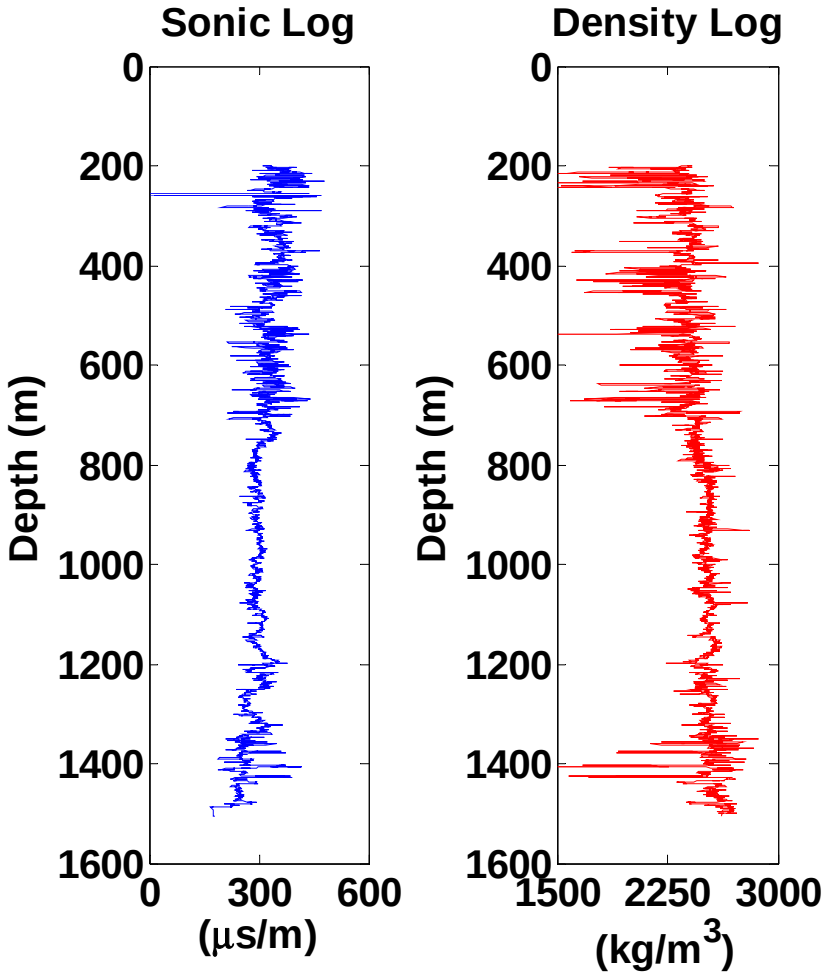
4 Steps to Create a Well Tie

- Edit the sonic and density logs.
- Calibrate the sonic log to seismic times.
- Create the synthetic reflection coefficients in two way time
- Determine the best match location and estimate wavelet at the location

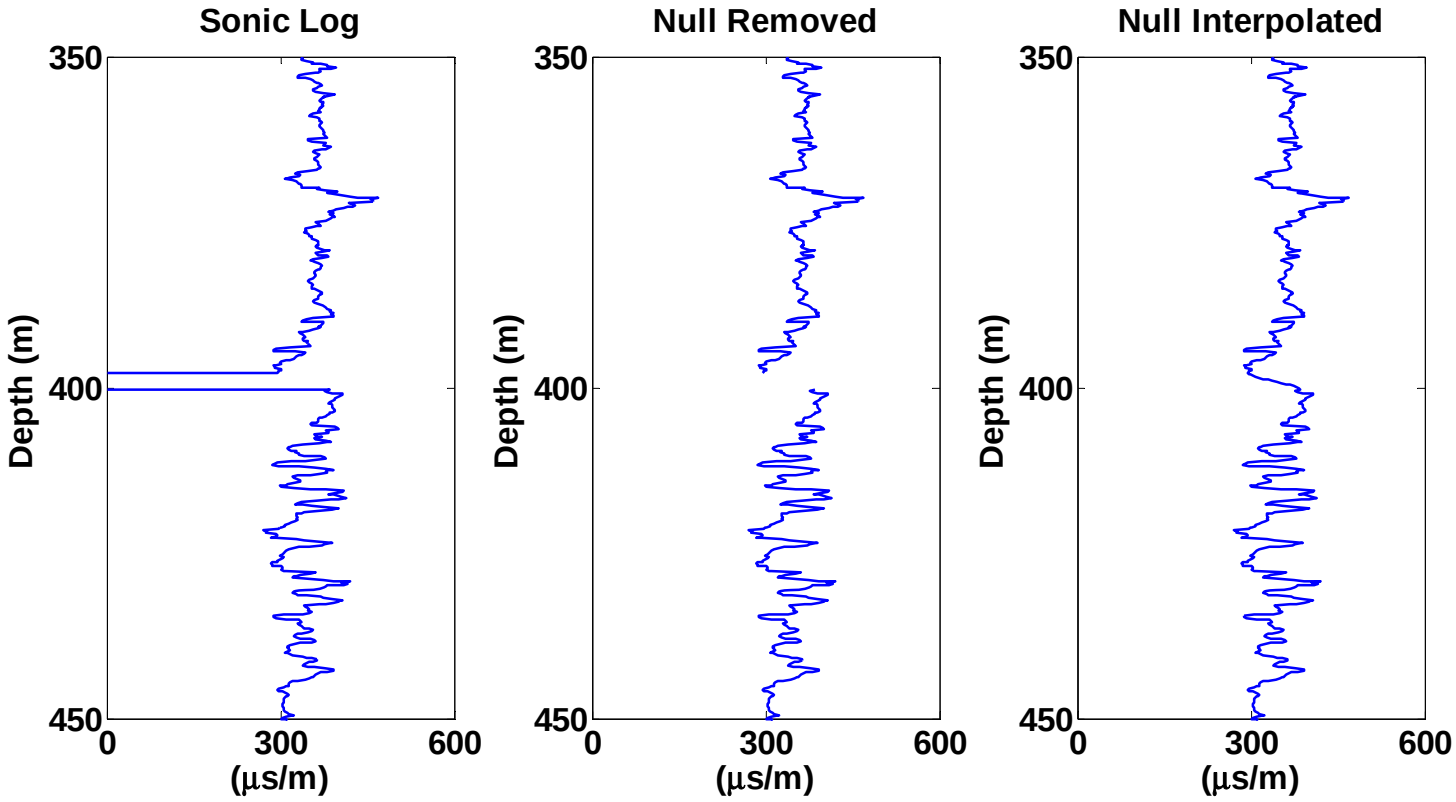
(White and Simm 2003):

Editing Logs

- Removing null values
- Applying an Overburden
- Clipping anomalous values
- Removing cycle skipping

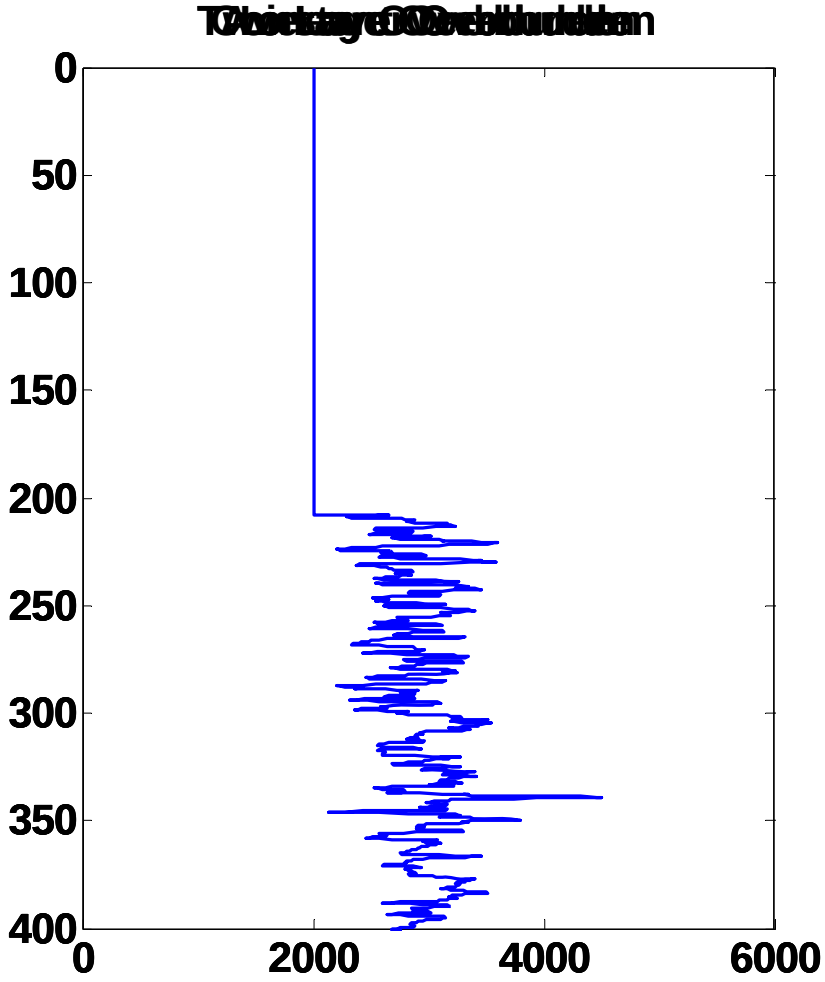


Remove Null values

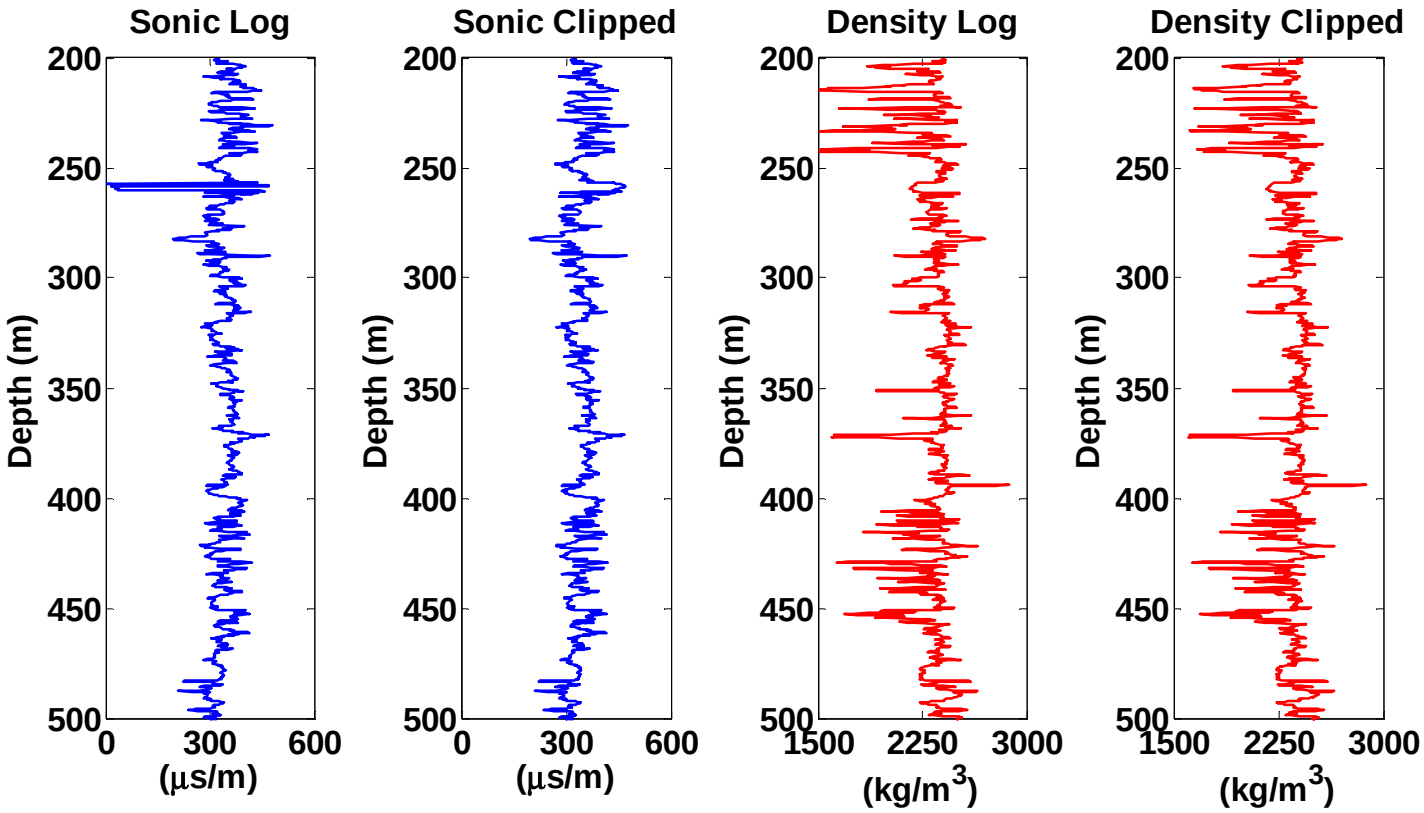


Selecting an Overburden

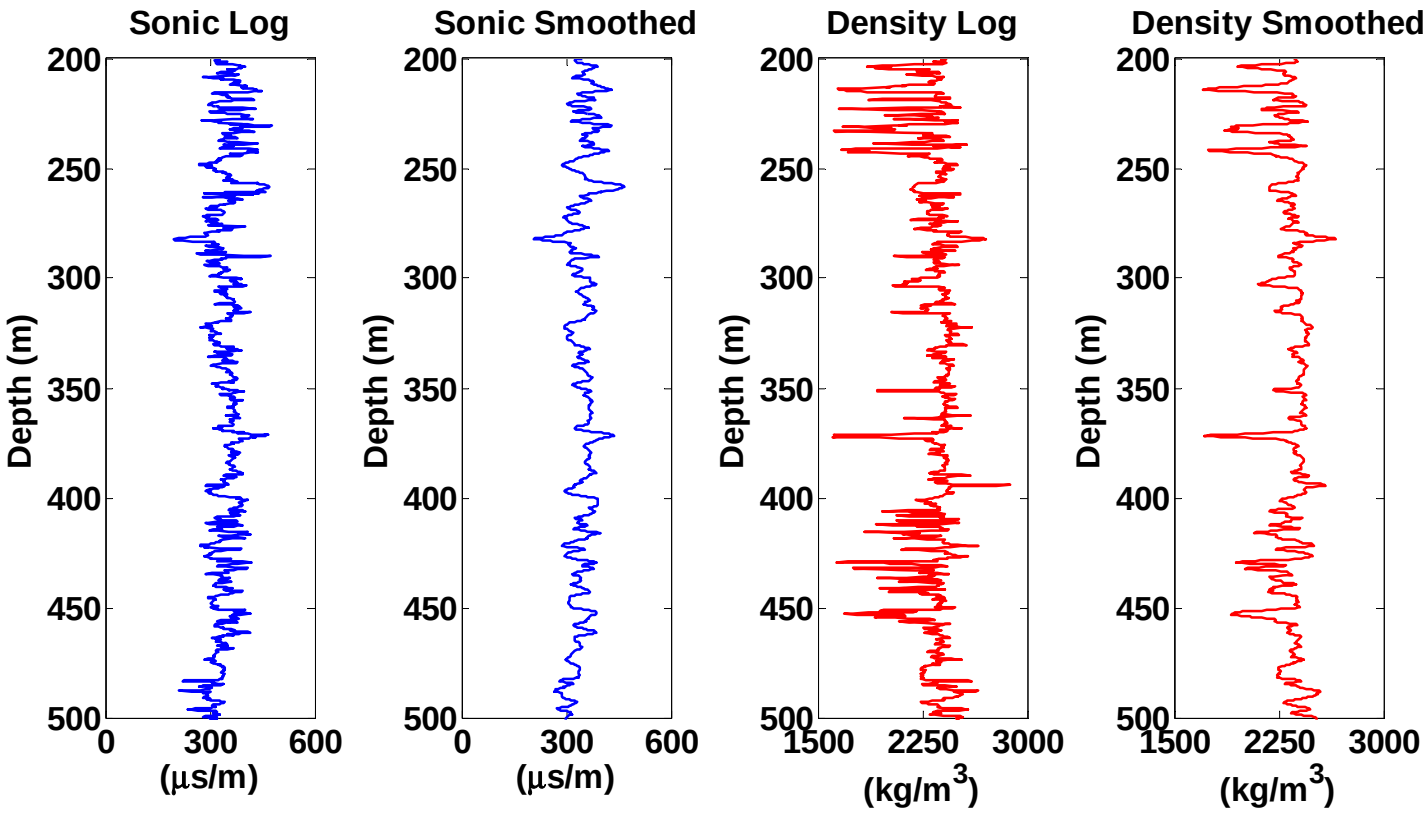
- Constant
- Linear
- Average
- Two Layer (Marine)
  - Constant
  - Linear
- Statics



Clipping Anomalous Values



Removing Cycle Skipping



Calibrating Time-Depth Relationship

- Why is this necessary?
  - Well logs are rarely measured to the surface
  - Seismic velocities are different from sonic tool velocities

$$V(f) \approx V_o \left(1 + \frac{1}{\pi Q} ln \left|\frac{f}{f_o}\right|\right)$$

(eg. Margrave,2010)

Calibrating Time-Depth Relationship

- Calibrate to VSP or Checkshots
- Use a stretch/squeeze algorithm to match events
- Use a stretch/squeeze algorithm to match envelope events
- Correct for attenuation effects

Comparison of Stretch and Squeeze Methods

Traditonal

- Matches Events
- Phase Sensitive
- Lots of event choices

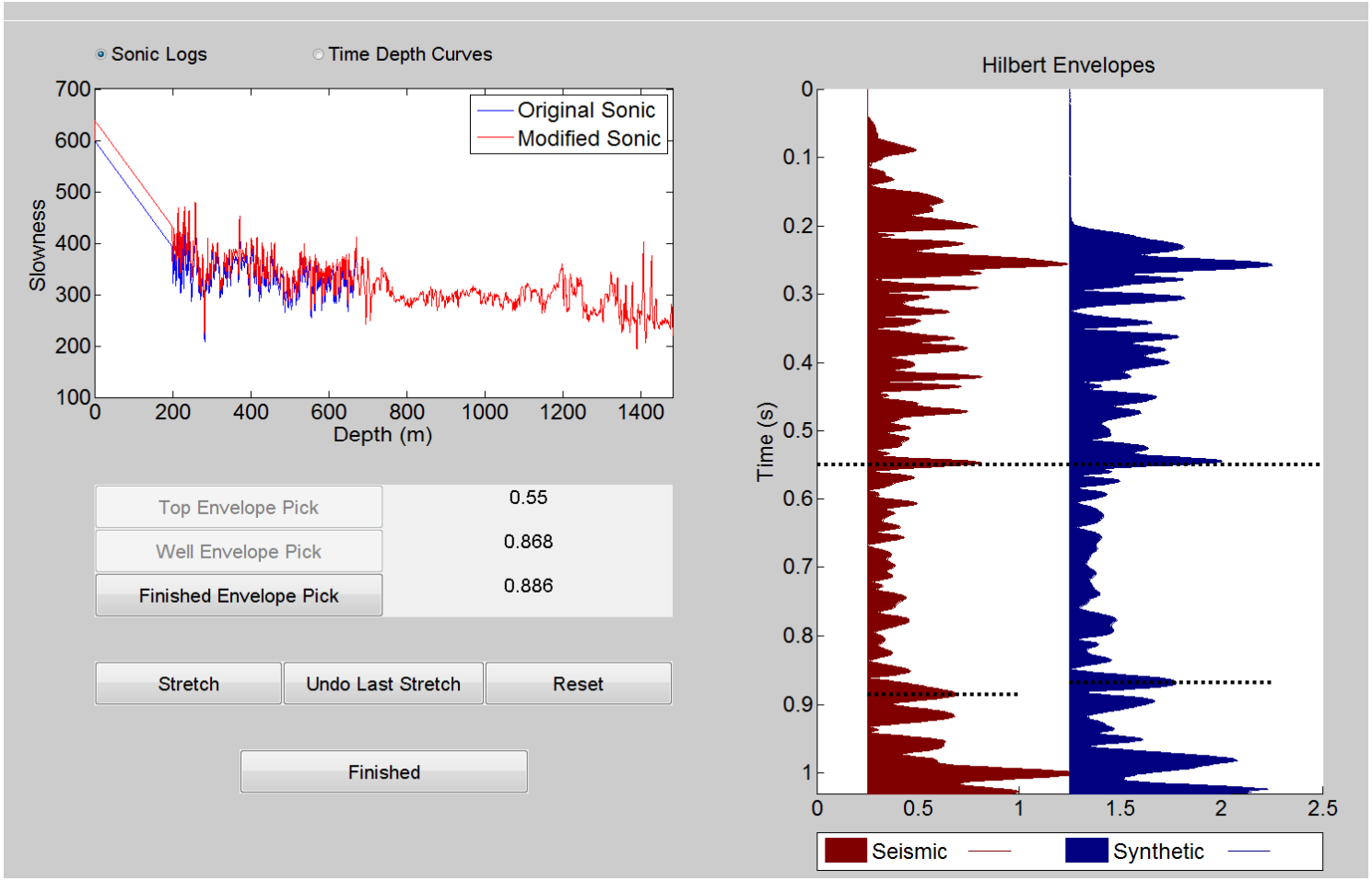
Envelope

- Matches Envelope Events
- Phase Insensitive
- Less choices

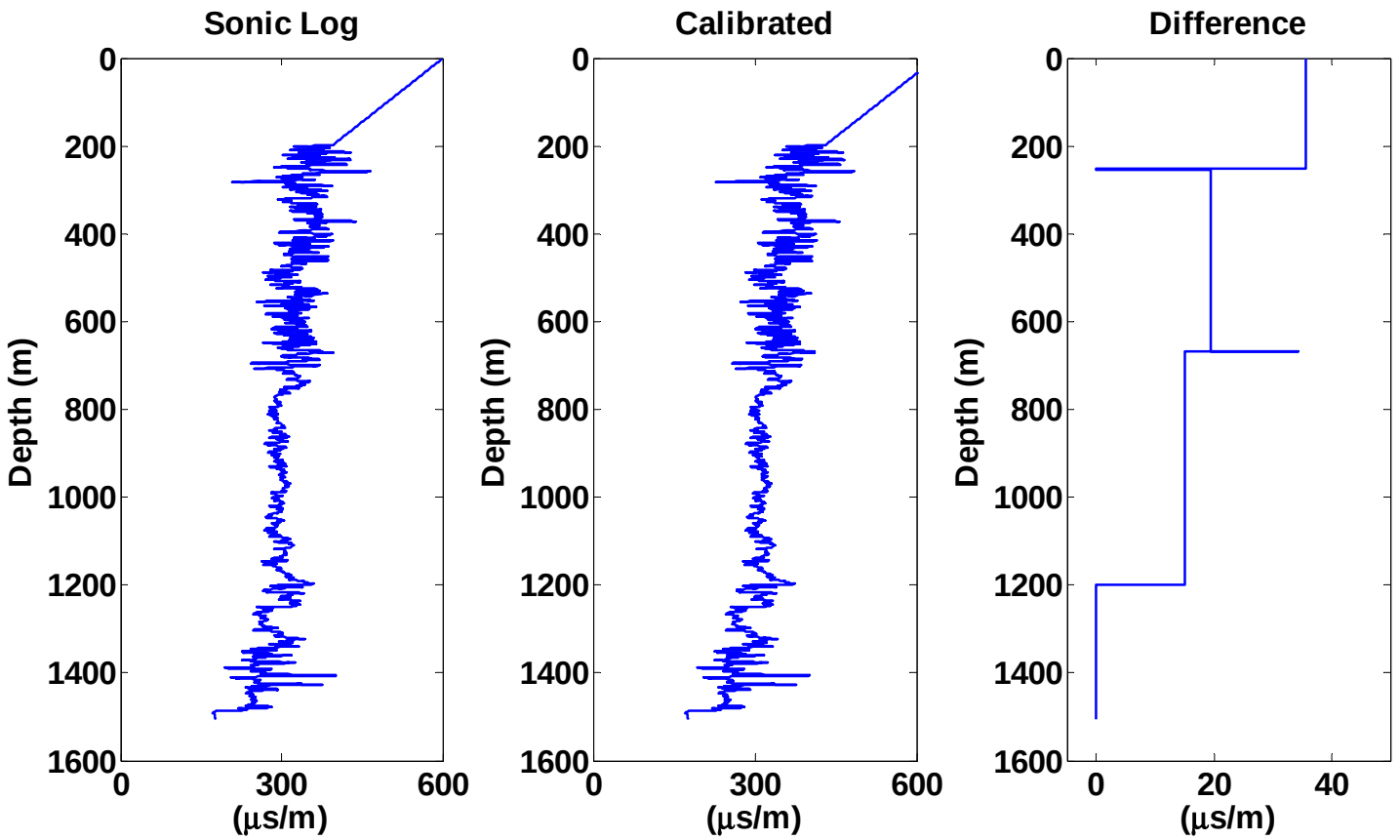
Adds or subtracts a velocity difference from the log based on picks made in an interval

$$H_{env} = \sqrt[2]{S(t)^2 + S^{\perp}(t)^2}$$

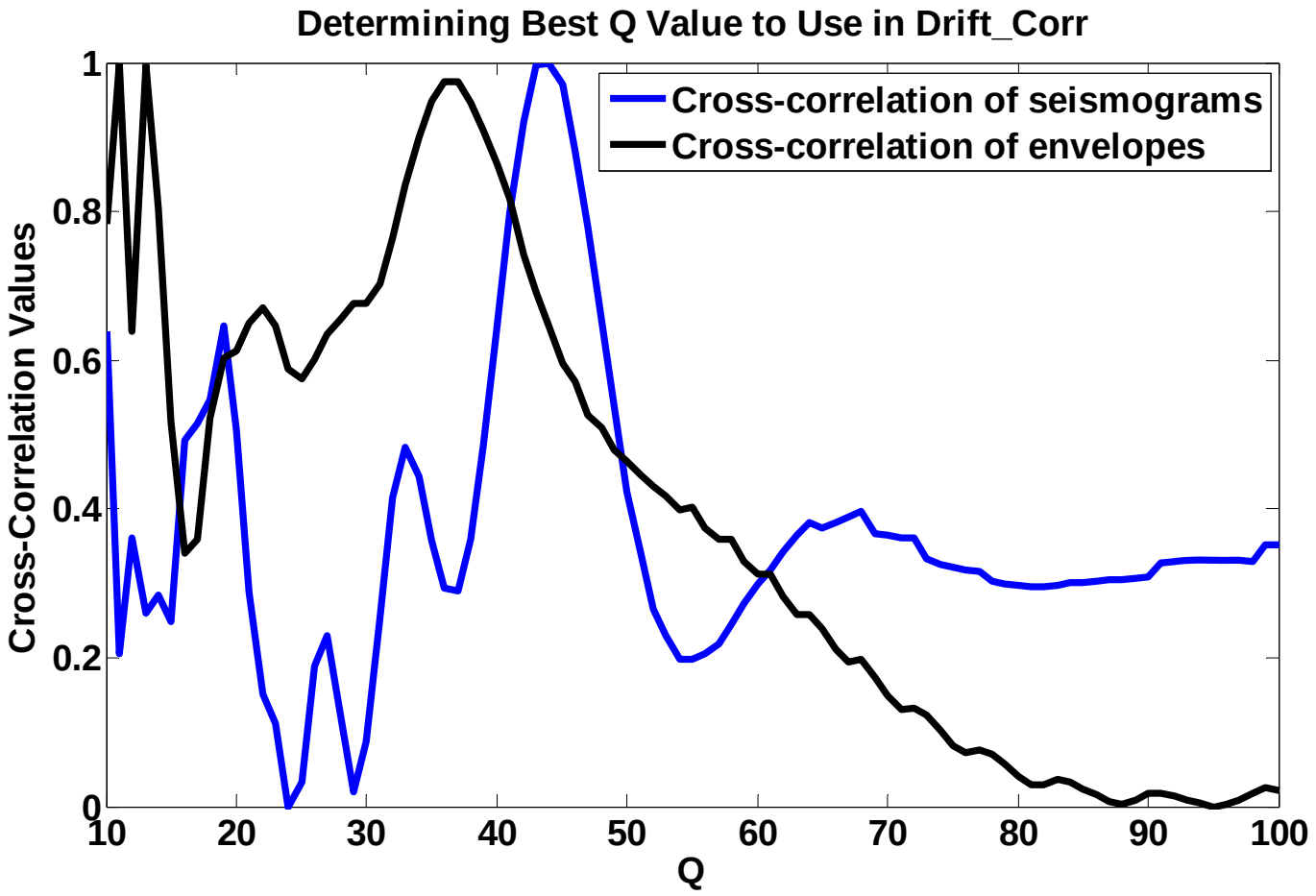
Envelope Stretch and Squeeze



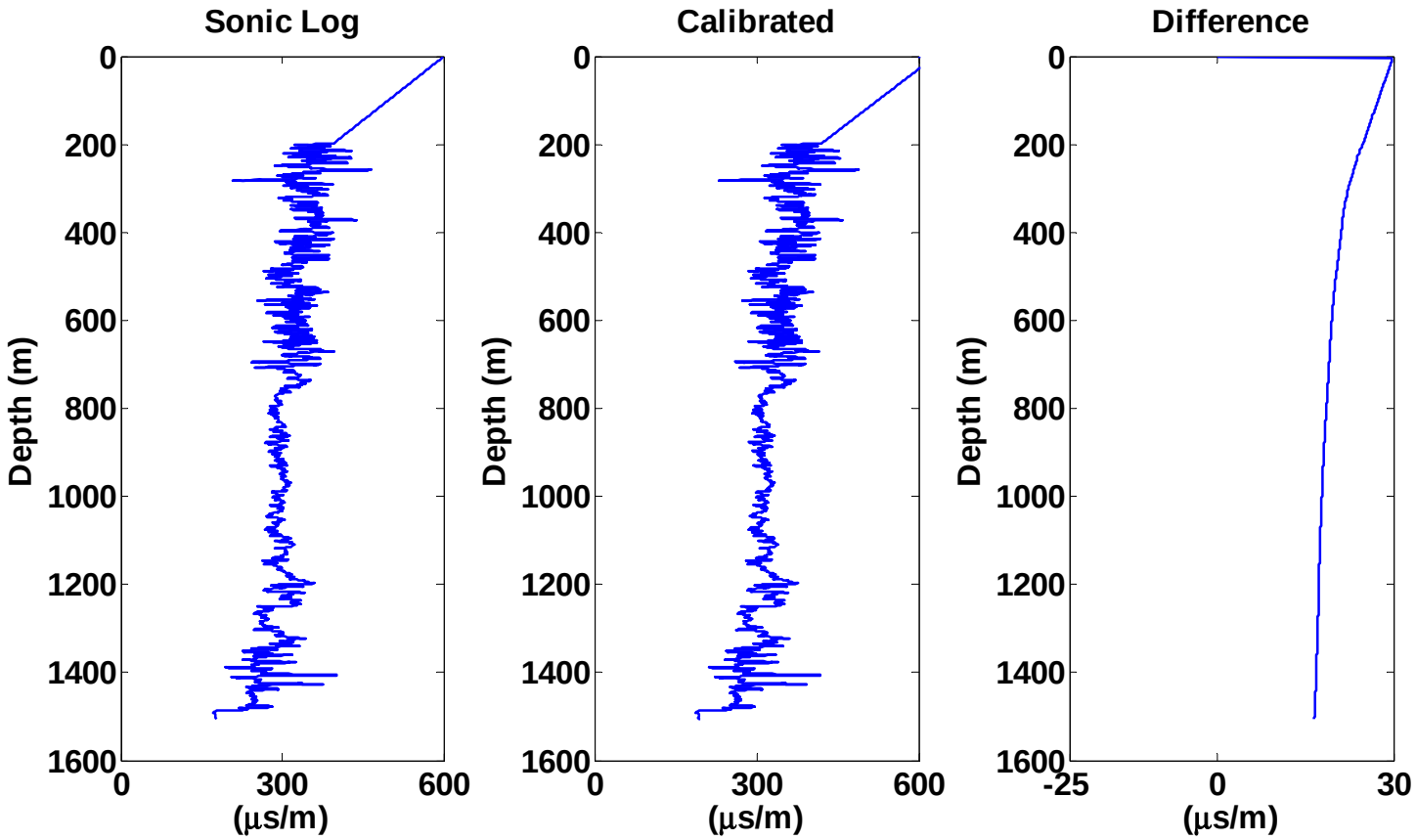
Envelope Correction



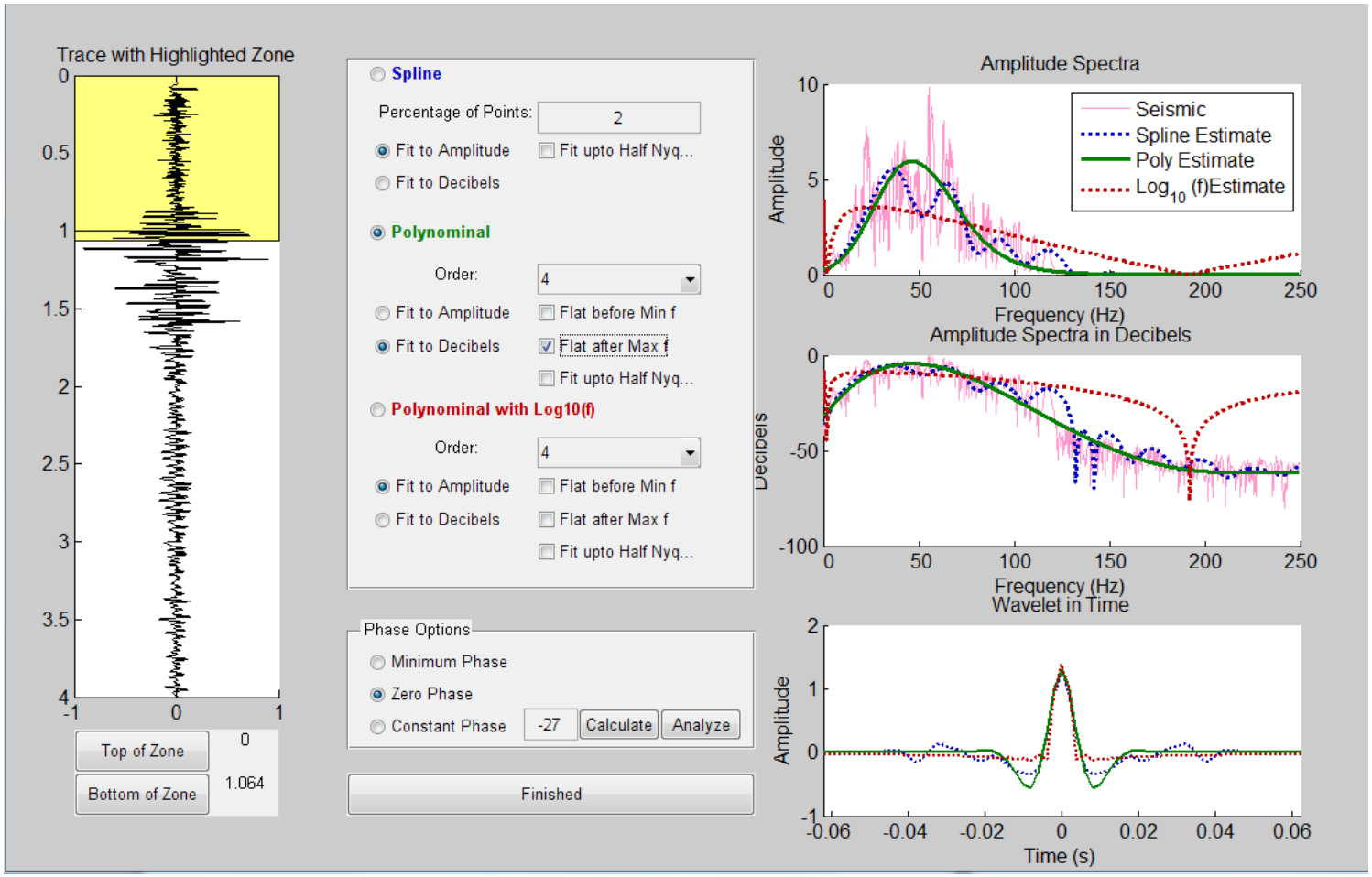
Attenuation Correction



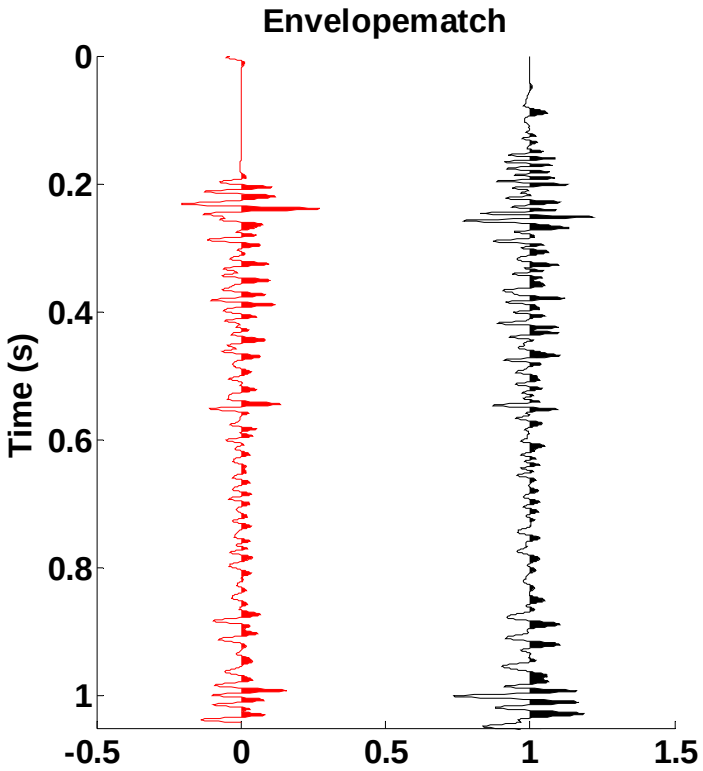
Attenuation Correction

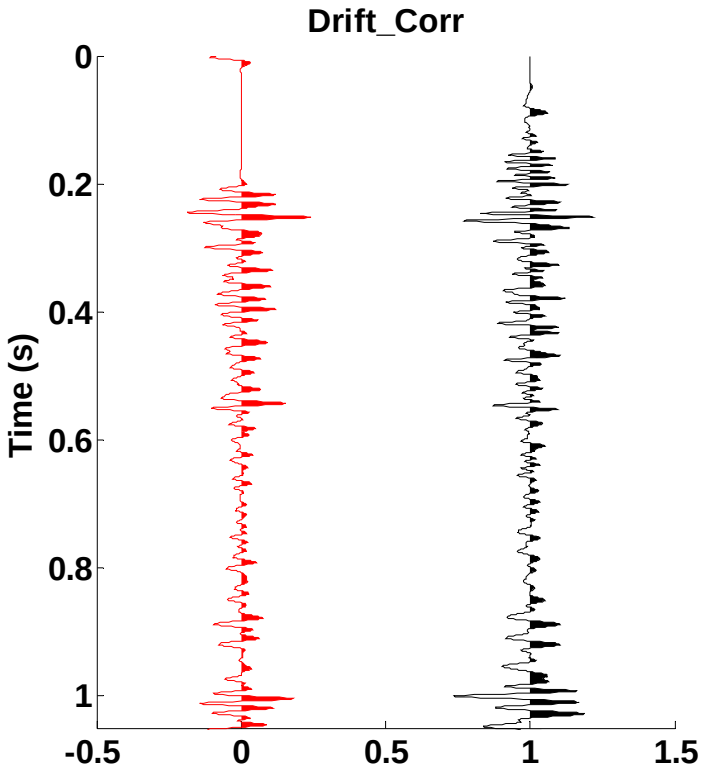


Wavelet Estimation

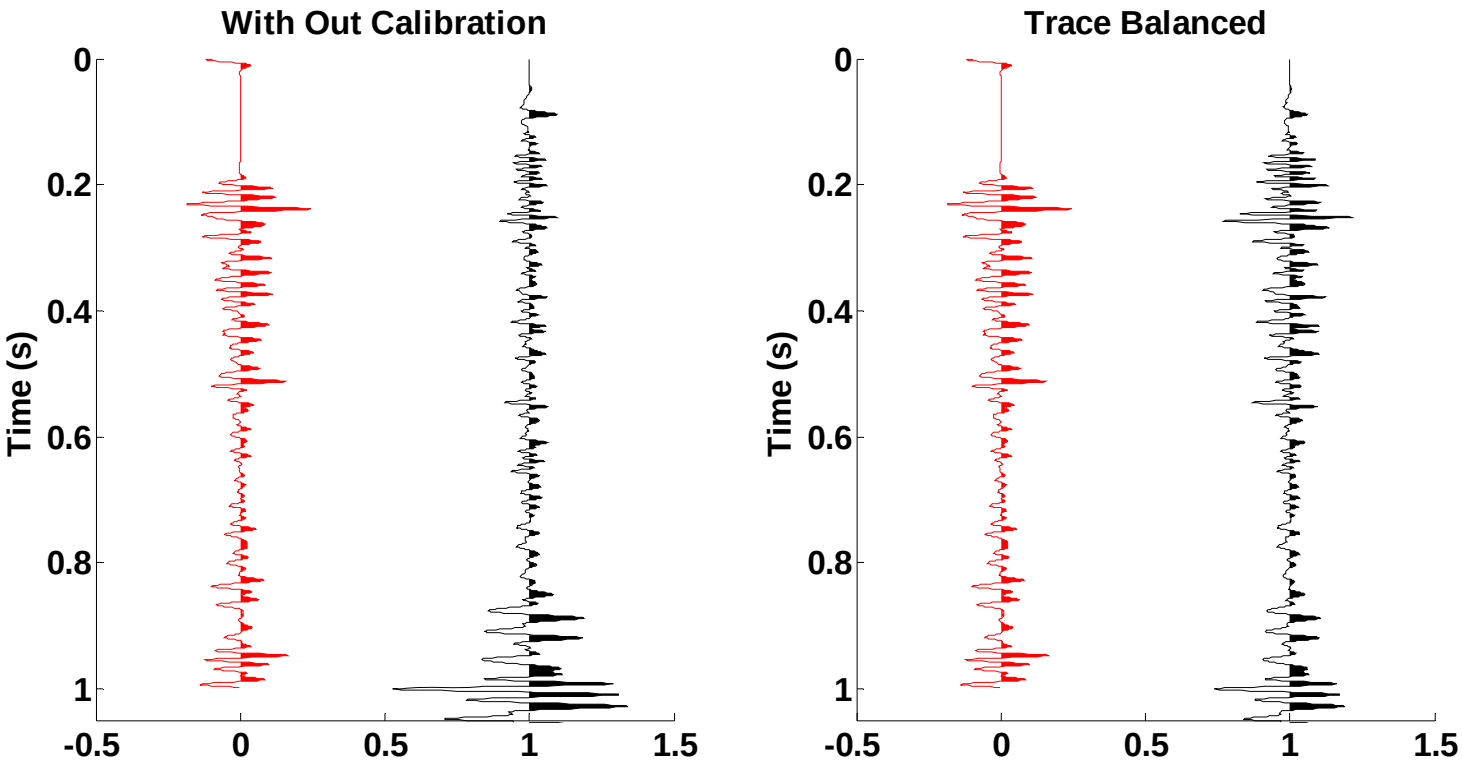


Comparison of Methods

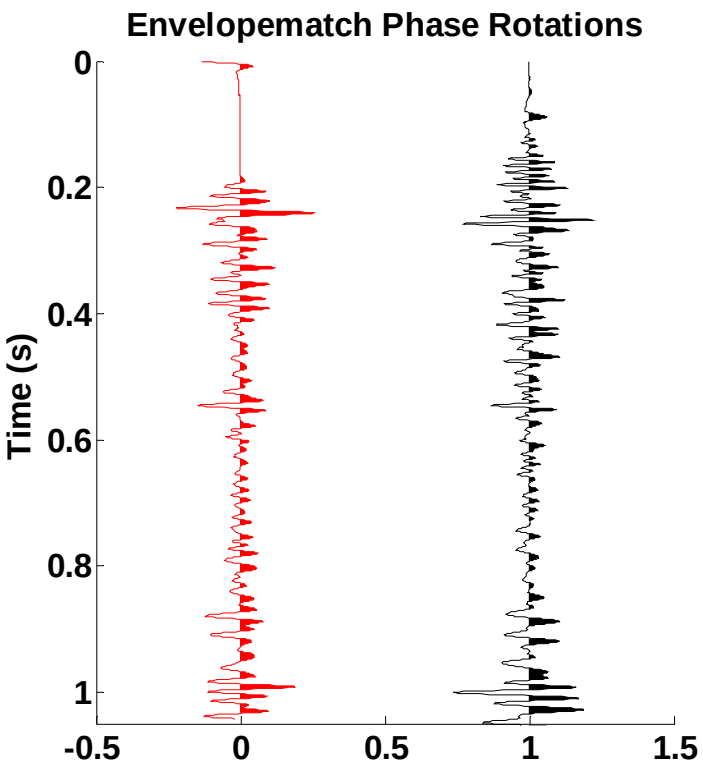


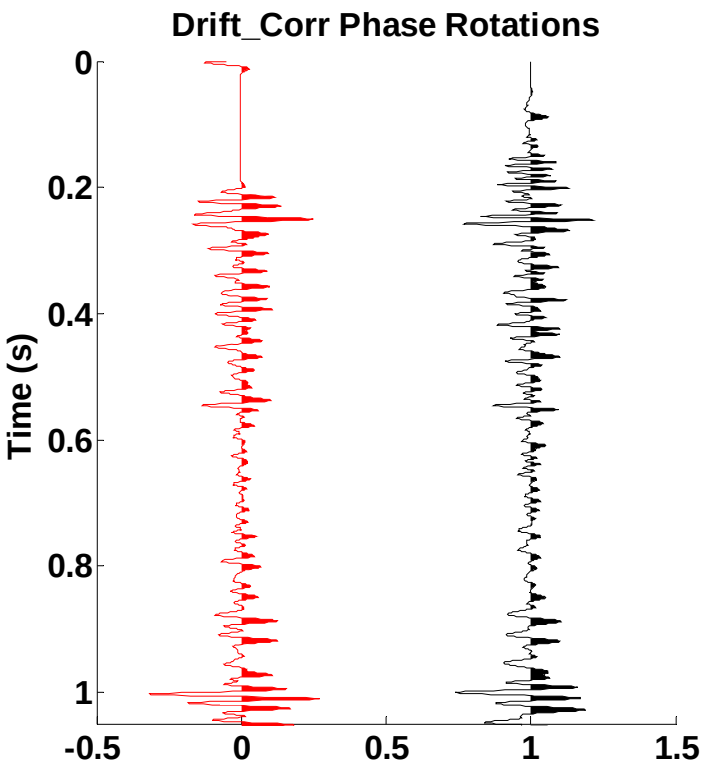


Balancing


With Out Calibration
Trace Balanced
Time (s)
0
0.2
0.4
0.6
0.8
1
-0.5
0
0.5
1
1.5

Time Variant Rotations





Acknowledgments

- CREWES Sponsors
- CREWES Staff
- CREWES Students
- Kevin Hall

References

- Margrave, G. F., 2010, Methods of Seismic Data Processing – Geophysics 517/557 Course Notes: The Department of Geoscience, University of Calgary
- White, R., and Simm, R., 2003, Tutorial: Good practice in well ties: First Break. Vol 21. pp75-83.

Useful MATLAB Functions

- readlas – loads logs from a LAS file
- SEGY_read – loads seismic from a SEGY file
- logoverburden – adds overburden to logs
- seismo – creates synthetic seismograms from well logs
- seismotz – similar to seismo but allows different sonic logs to be used for time depth relationships and reflection coefficients

Useful MATLAB Functions

- cliplogs - Clips logs that have values outside the range that a user specifies
- removenull - Removes null values and interpolates between them
- bcarsmooth - Smoothes the log with a boxcar operator
- Cscali - Applies corrections to a sonic log from time-depth pairs from checkshots or VSP data
- drift_corr - Applies corrections to a sonic log and synthetic from a Q model

Useful MATLAB Functions

- stretchwell – a GUI interface that allows the user to match up events on seismic and a synthetic seismogram. Outputs a new sonic log
- envelopematch – a GUI interface that allows the user to match up envelope peaks on seismic and a synthetic seismogram. Outputs a new sonic log

Useful MATLAB Functions

- waveletestimator – estimates wavelets from seismic
- waveleteditior – creates standard wavelets (ormsby, ricker, ect.)
- convz – convolves reflectivity with a zero phase wavelet
- convm – convolves reflectivity with a minimum phase wavelet

Useful MATLAB Functions

- balans – balances amplitudes between seismic and synthetic traces
- tvbalans – balances amplitudes in Gaussian windows
- constphase – calculates a constant phase rotation
- phsrot – applies a constant phase rotation
- tvlsphsrot – calculates a constant phase rotation in Gaussian windows and applies it to a seismic section

Useful MATLAB Functions

- wtva – plots one trace in wiggle trace variable density display
- plotseis – plots a seismic section in wiggle trace variable density display
- plotimage – plots seismic as a variable density display with black to white colormap