GEOPHYS 242: Near Surface Geophysical Imaging

Class 9: Short-Wavelength Residual Statics Corrections
Fri, April 22, 2011

- Residual statics concepts
- Refraction traveltime methods
- Reflection and refraction wavefield methods

Short-wavelength residual statics (about 10 ms or less) may not be able to be resolved through the near-surface model imaging, but critical for seismic stack quality. This class shall review the technologies for deriving residual statics after obtaining long-wavelength statics solutions.

Seismic Static Corrections
(Desperately needed for processing land seismic data in order to see something in the subsurface!)

Statics: time shift for each shot and each receiver position. That means, each seismic trace includes two correction numbers: shot statics + receiver statics

Statics Corrections also include long-wavelength and short-wavelength statics, and each plays different roles.

Long-wavelength statics:
a) Must be less than 200 ms, affects the shape and quality of subsurface image
b) Usually calculated through a near-surface velocity model (model based)
c) Corrections for relatively large near-surface structure effects
d) Usually changed shot and receiver positions (elevation) after the corrections

Short-wavelength statics:
a) Usually less than 10 ms, affects the quality of subsurface image
b) Usually calculated through data itself, without a model involved
c) Corrections for small near-surface structure effects
d) Shots and receivers stay at the same positions.

Surface Consistency:
Both long- and short-wavelength statics corrections are required for "surface consistency."

Questions:

1) Why long-wavelength statics is required to be less than 200 ms?
2) Why does long-wavelength statics calculation require down- and up-going path and a replacement velocity?
3) In what situation that "surface consistency" fails?

Long-wavelength statics solutions:
Primarily involves resolving a near-surface velocity model by one of the following approaches:

- Refraction traveltime interpretation
- Refraction delay-time method
- Refraction traveltime and wavefield migration
- First-arrival traveltime tomography
- Early-arrival waveform tomography
- Dispersion-curve inversion

Short-wavelength statics solutions:

Before migration:

- Refraction data-based traveltime residual analysis
- Refraction model-based traveltime residual analysis
- Reflection stack-power maximization
- Refraction stack-power maximization

After migration:

- Reflection stack-power maximization

References:

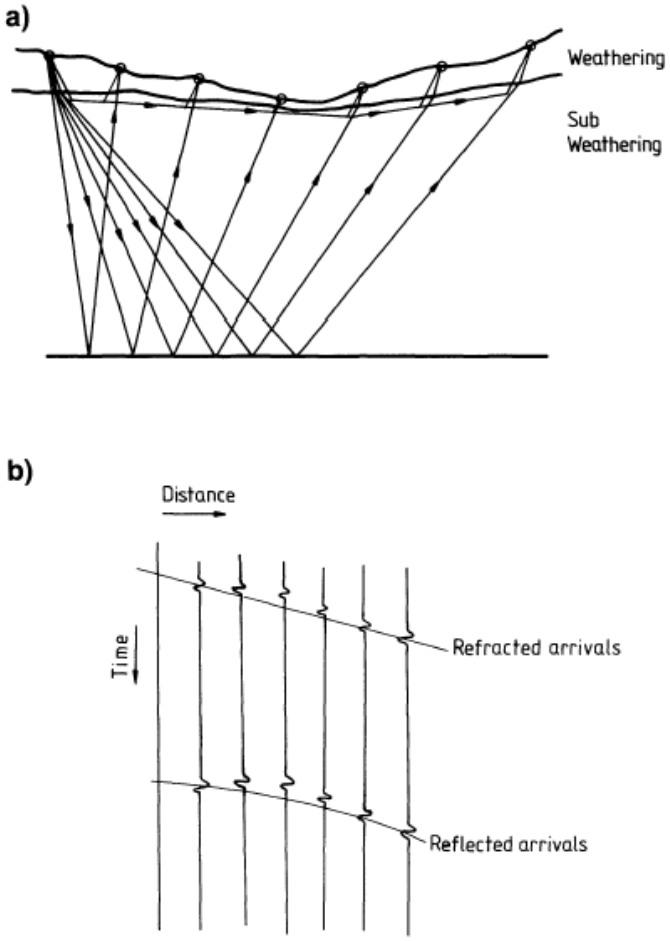
Ronen, J. and J. F. Claerbout, 1985: Surface-consistent residual statics estimation by stack-power maximization, *Geophysics*, Vol 50, 2759-2767.

Hatherly, P., M. Urosevic, A. Lambourne, and B. J. Evans, 1994: A simple approach to calculating refraction statics corrections, *Geophysics*, Vol 59, 156-160.

Software Packages:

- Every data processing package
- MASTT - L1-norm solution, by TECHCO

Refraction traveltime method:
Assumptions: same near-surface effects on both refraction and reflections



1) Given refraction traveltimes t_{ij}: *ith* source, *jth* receiver
2) Apply long-wavelength statics to traveltimes: $T_{ij} := t_{ij} + \Delta t$
3) Subtract by smoothed traveltimes, and the results: ΔT_{ij}

$\Delta ts_i + \Delta tr_j = \Delta T_{ij} \quad i=1, ns; j=1, nr$

Solve a set of linear equations iteratively

Model-based solution:

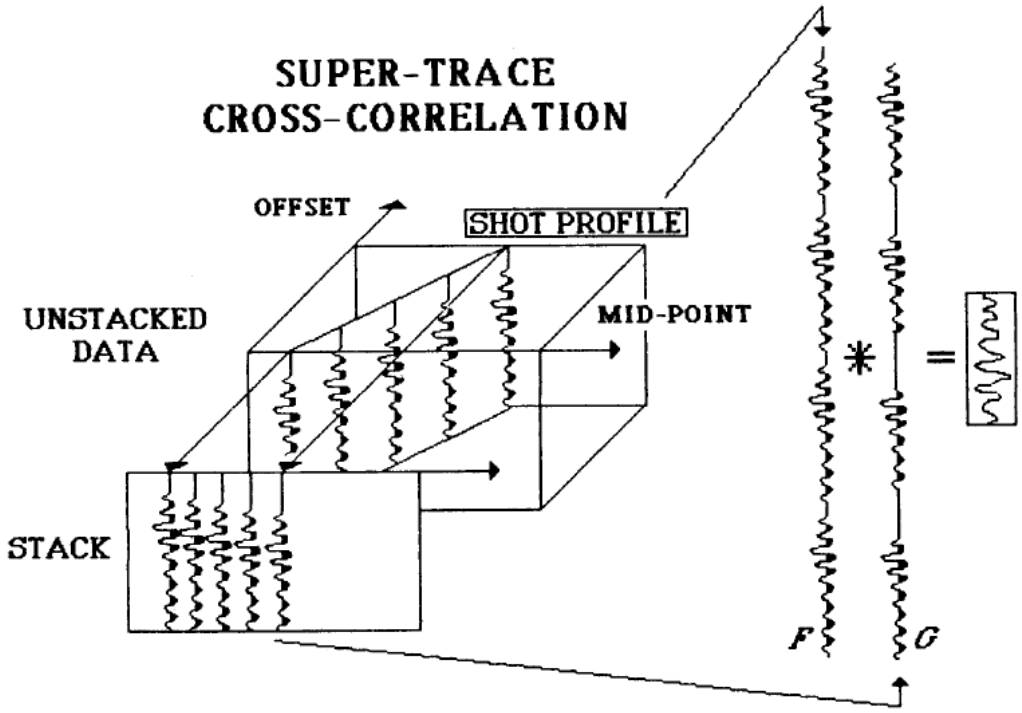
1) Given refraction traveltimes t_{ij}: *ith* source, *jth* receiver
2) Subtract by calculated traveltimes, and the results: ΔT_{ij}

$\Delta ts_i + \Delta tr_j = \Delta T_{ij} \quad i=1, ns; j=1, nr$

Solve a set of linear equations iteratively

Reflection stack-power maximization method:

1) Conventional processing, CDP stack
2) Iterative process



For every shot and every geophone:

Iterative process:

1) Form the super traces
2) Crosscorrelate them
3) Pick the maximum
4) Correct the stack

Questions:

1) With several hundreds of traces per shot, super trace is very long, any trick to save calculation time for crosscorrelation?
2) Why not correlate with trace by trace instead of supertrace?