Class 9: Beyond Seismic Statics Corrections
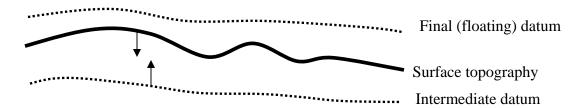**Wed, Oct 7, 2009**

- Dynamic corrections: wave-equation and wavefield datuming methods
- Skipping the near-surface by interferometry (no model needed)
- Common-Focus Point (CFP) method (no model needed)

This class introduces alternative approaches in dealing with the near-surface problems in seismic imaging as opposed to making statics corrections. Dynamic corrections involve applying wave theories to propagate the data using the near-surface velocity model. Therefore, there is no more straight-ray assumption. However, wave-equation and wavefield datuming approaches are very different: first one requires regular shot and receiver geometry while the second one only requires regular receiver geometry.

Interferometry and CFP methods offer another types of approaches that do not require any near-surface velocity model. Both methods redatum the seismic data to a reflector below the near-surface area without using the near-surface model. Due to tight schedules today, we are not going to invite any outside speaker to give presentation.

Wave-Equation Datuming:
One-way wave-equation extrapolator, downward and upward continuation
Requirements: regular shot and receiver geometry (even spacing) – data regularization

Final (floating) datum

Surface topography

Intermediate datum

Downward propagation: using true near-surface velocity model, one-way wave-equation extrapolator:

Upward propagation: using a constant (replacement) velocity

Two Steps: first for common-shot gathers, second for common-receiver gathers. And then sort it back to common-shot gathers for processing.

Results:
1) Remove the near-surface effects
2) Position shots and receivers at the final datum (smoother interface, better for migration)

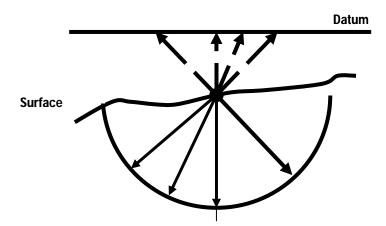**One-way wave-equation extrapolator (phase-shift method)**:

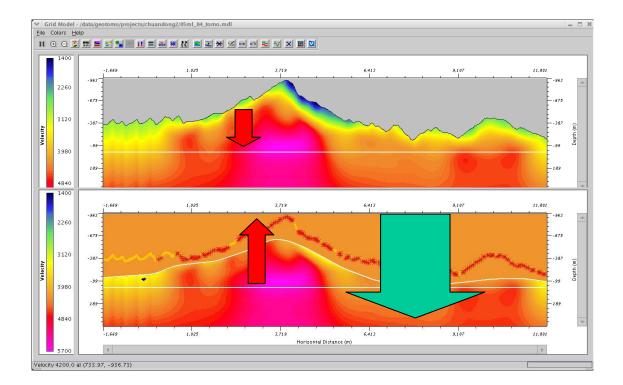$$U(k_x, z, \omega) = U(k_x, z - \Delta z, \omega) e^{-ik_z \Delta z}$$

Yang et al., 2009, Application of an integrated wave-equation datuming scheme to overthrust data: A case history from the Chinese foothill, Geophysics, Vol 74, B153-B165.

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Wavefield Datuming:

1) Datum common-shot gathers
2) Datum a shot wavefront
3) Avoid dealing with common-receiver gathers
4) Do not output redatumed gathers, just in the migration process
5) Good for PSTM imaging. For PSDM, just part of the migration

Interferometric Datuming
Position shots and receivers down to reference datum. Within a shot gather, using a reflection event from reference datum to correlate the entire shot gathers. You are done! (Sounds too good to be true!)

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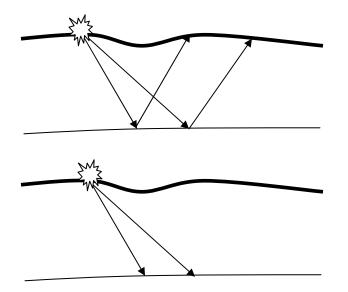**Wait a minute: I do not know where the reflection is from!**

To determine the reflector position for the operator:

1) The reference reflection should be windowed in each shot gather. If visible, then times of reflections are picked. Otherwise just use the windowed arrivals only for redatuming or migration. The depth of the reference reflector should be estimated (this can be done in time domain so T_0 is given from data) at z_0.

2) Initially assume a flat reflector. Therefore, the picked reference reflection times are divided by 2 and these traces are now fake VSP direct arrival times (if using windowed traces then divide travel time axis by the value two). The location of the fake VSP geophones are at depth z_0 and at the midpoint location $x_0=(x_g+x_s)/2$ for a reference trace with source at x_s and geophone at x_g.

3) Each fake VSP geophone will be associated with a fake direct arrival trace as described above.

4) Use these fake VSP traces to migrate the data. If the reference reflector appears in the migration image then its dipping geometry can be used to adjust the locations of the geophones in the fake VSP geometry. And the procedure can be iterated until some type of convergence.

A shot gather (reference reflection marked):

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a) Migration with true near-surface model
b) Migration with incorrect near-surface velocity model, but true subsurface model
c) Migration of interferometric gathers without using the near-surface model

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(Synthetic example from Prof. Jerry Schuster)

Common-Focus Point (CFP) Method

Three papers discussed common-focus-point (CFP) gathers in SEG 1996:

Seismic processing between two focusing steps, by A.J. Berkhout
Migration velocity analysis using the common focus point technology, by M.M. Nurul Kabir and D.J. Verschuur,
Automating prestack migration analysis using common focal point gathers, by Scott A. Morton and Jan Thorbecke.

CFP presents a new way to interpret and perform migration.

According to CFP technology:
Prestack migration in terms of two steps (whichever first):

1) **Focusing in emission**: placing a virtual source at a grid point, but leaving receivers at surface (CFP gathers, half migrated data)
2) **Focusing in detection**: placing receivers to the grid point, leading to another image.

Principle of equal time: if the grid point in the first focusing step is chosen at a reflector and if the correct operator has been used for the synthesis operation, the response of the reflector appears in the CFP gather at the same traveltimes as the time reversed synthesis operator.

3) By a correlation in time of the CFP gather and its corresponding synthesis operator, and aligned event at zero time should occur. If not, using the time shift to adjust the operator.

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Kelamis et al., 2002, Velocity-independent redauming: A new approach to the near-surface problem in land seismic data processing., TLE, August 2002, P730-735.

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