3C wave mode separation and preSDM with topography

Saul E. Guevara, and Gary F. Margrave*
seguevar@ucalgary.ca

- SUMMARY

Scalar methods for multicomponent data processing require separate wave modes. A method such a wave mode separation in the presence of topography is proposed and tested on synthetic seismic data, generated on a complex geology model with a 2D elastic FD method. The resulting data are migrated using two preSDM approaches, Kirchhoff and PSPI, and also taking into account the rough topography. The seismic images obtained show the challenging characteristics of these data; however the methods provide insights into an approach that can be rewarding for elastic wave processing in complex settings.

- WAVE MODE SEPARATION AND THE FREE SURFACE EFFECT

Reflections from deeper layers are affected by reflections and wave mode conversions at the free surface, and recorded by vertical and horizontal components. An example of the relation between them is in **Figure 1**, assuming incident plane waves. It allows a *mode separation method* using the Tau-p transform.

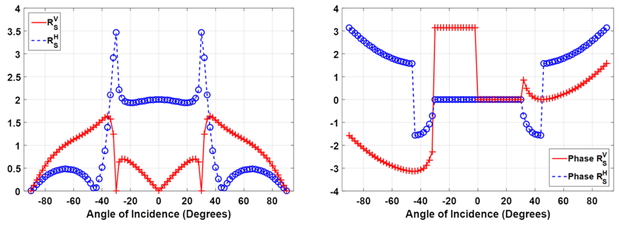

FIG. 1

- MODE SEPARATION WITH TOPOGRAPHY

The surface slope should be taken into account In the case of topography. **Figure 2** illustrates the required rotation of the seismic data. The Tau-p transform allow the plane wave decomposition of the seismic record, such that the Free surface coefficients (Figure 1) can be applied to obtain the incident wave at each receiver.

To obtain the angle of incidence at the receiver, shot gathers are required (**Figure 3**). A local Tau-p transform was used applying a Gaussian gate, taking into account the horizontal variations in the elastic properties (velocities) and the topography.

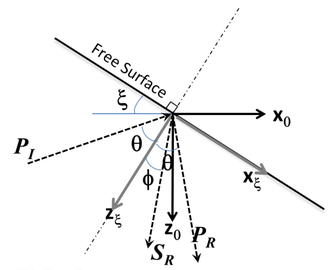

FIG. 2

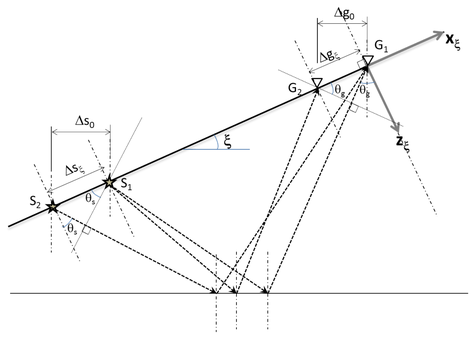

FIG. 3

- MIGRATION METHODS

The resulting data are migrated using two preSDM approaches, Kirchhoff and PSPI, which also take into account the rough topography.

- APPLICATION TO SYNTHETIC DATA

To test the method synthetic data were obtained from a complex geology model, using a elastic 2D FD method. The model is in **Figure 4**.

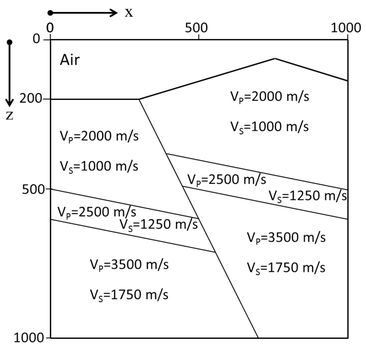

FIG. 4

Figure 5 shows an example of the resulting records, 5a the vertical and 5b the horizontal components. **Figure 6** shows the result after wave mode separation, 6a the P-wave and 6b the S-wave. Compare with **Figure 7**, P-wave (7a) and S-wave (7b) arrivals obtained with ray-tracing.

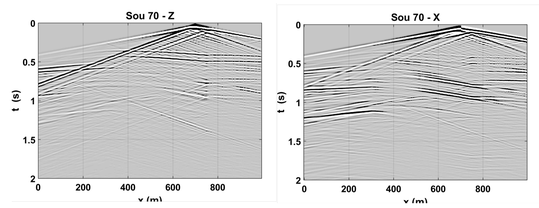

FIG. 5

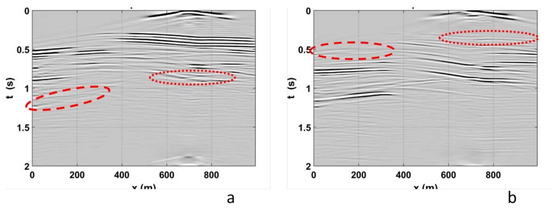

FIG. 6

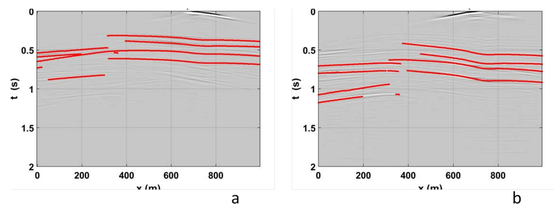

FIG. 7

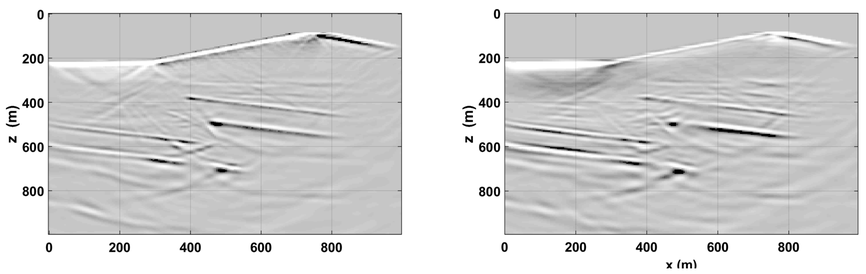

FIG. 8

Migration result using the PSPI algorithm. The horizontal component to the left, and the separated S-wave to the right-hand side. Minor differences can be noticed.

- CONCLUSIONS
- The example, from a complex model and using FD modeling, shows reasonable resulting wave mode separation, even though with residual leakage. However the migration results are not as rewarding as expected, which could be attributed to shortcoming in the theoretical model and the nature of the Tau-p transform.
- The seismic images obtained show the challenging characteristics of these data; however the methods provide insights into an approach that can be rewarding for elastic wave processing in complex settings.