A NOVEL METHOD FOR DEVELOPING AND IMPLEMENTING HYBRID BORN-RYTOV AVO APPROXIMATIONS

Anthony Barone and Mrinal Sen

Department of Geological Sciences
The University of Texas at Austin

ABSTRACT
Over the past several decades, Amplitude-vs-Offset (AVO) technology has proven to be an extremely valuable resource in exploration geophysics due to its ability to detect directly hydrocarbons in the subsurface. AVO approximations have opened up new domains for improved seismic data interpretation and have allowed for significant computational savings when forward modeling seismic reflections. In this work we propose a new method for constructing AVO approximations. This method is based on a framework that seamlessly spans the Born and Rytov approximations to seismic wave propagation. It can be customized to produce either Born-like, Rytov-like, or mixed Born-Rytov solutions. We describe three potential methods for developing AVO approximations using the Hybrid Born-Rytov method. All initial work is done under the assumption of isotropic media although these methods can be easily modified to work in an anisotropic setting. Preliminary results show that Hybrid Born-Rytov AVO approximations are potentially more accurate than many traditional AVO methods in isotropic media. We believe that these AVO approximations will reveal new approaches for interpreting AVO information. Furthermore, they should ultimately prove to be more accurate and interpretable than conventional AVO approximations, especially in anisotropic media.
Comparisons of Hybrid Born-Rytov AVO solutions for three layer interfaces that are representative of a typical stratigraphic model. Columns (Left to Right) represent the Shale over Gas Sand, Gas Sand over Brine Sand, and Brine Sand over Shale cases. In all images, incident angles (θ) ranging from 0 – 50 degrees are shown. These AVO solutions were generated using the third method described in this paper, which is the Hybrid Born-Rytov method recommended by the Authors. (Upper Row) Hybrid Born-Rytov AVO solutions for a range of tuning parameters. Values of “tuning parameter” \( \eta \) ranging from 1 (Born-limit) to ~1.2 million (Rytov-limit) are used. Solutions corresponding to small values of \( \eta \) are shown in blue, whereas solutions corresponding to large values of \( \eta \) are shown in green. The Zoeppritz solution is shown in red. (Middle Row) The best-fit Hybrid Born-Rytov solutions. Fit was determined based on closeness to the Zoeppritz solution. The 2- and 3-term Aki-Richards AVO approximations are also shown to allow for a direct comparison to other approximate AVO methods. The best-fit reflectivity curve is in blue, the Zoeppritz solution is in red, and the 2- and 3-term Aki-Richards AVO approximations are in dashed green and cyan, respectively. (Lower Row) The value of \( \eta \) needed to generate the best-fit Hybrid solution as a function of incident angle, described using a logarithmic scale. In all cases the ideal value of \( \eta \) is angle dependent. The Born-limit (\( \eta = 1 \)) appears to always be best at normal incidence; however, the ideal value of \( \eta \) tends to increase with increasing incident angle. Future work will investigate if the angle-dependent nature of \( \eta \) can be linked to rock properties.