AVO modelling of linearized Zoeppritz approximations

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Abstract

The reflection coefficients are investigated for the various approximation on Zoeppritz equation and the results compared with the exact solution. There some deviations near critical angles that for larger layer contrasts and larger angle of incidence these deviation are significant. Also, the effect of γ parameter on forward modelling is investigated. When the contrasts between the layers of model is larger, the γ parameter has more influence on forward modelling.

Approximation of the Zoeppritz equations

Zoeppritz's equations completely determine amplitudes of reflected and transmitted plane waves for all incidence angles. In order to gain more insight into the factors that control amplitude changes with angle/offset, and simplify computations, linearized approximations to the Zoeppritz equations have been developed. There are several approximation that we want to consider them and compare their results.

Comparison of approximations to the exact solution

The results of different approximation are compared to the exact equation. The geologic parameters are given in Table 1. The reflection coefficients are calculated and plotted against the angle of incidence up to the critical angle.

Model	$V_{P0}(m/s)$	$V_{S0}(m/s)$	$\rho_0(kg/m^3)$	$V_{P1}(m/s)$	$V_{S1}(m/s)$	$\rho_1(kg/m^3)$
1	3000	1800	2200	3100	1900	2250
2	3000	1800	2200	3200	2000	2250
3	3000	1800	2200	4000	2500	2400
3	3000	1800	2200	4500	3000	2600

The various approximations are compared to the exact Zoeppritz equation for small layer contrast (model 1 and 2) and large layer contrast (model 3 and 4)

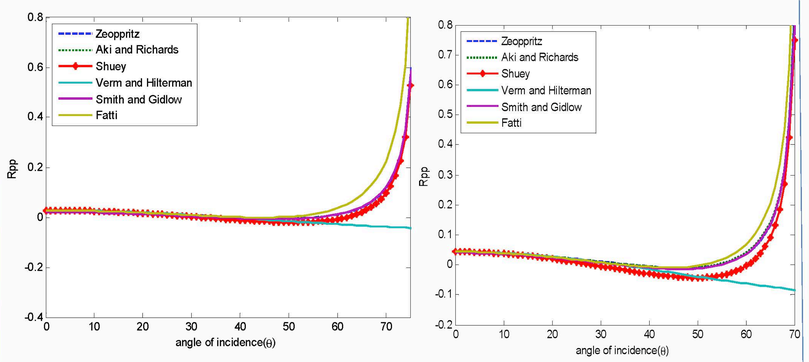

FIG. 1. Illustrate the reflection coefficients (Rpp) for different approximations using models 1 and 2 in Table 1.

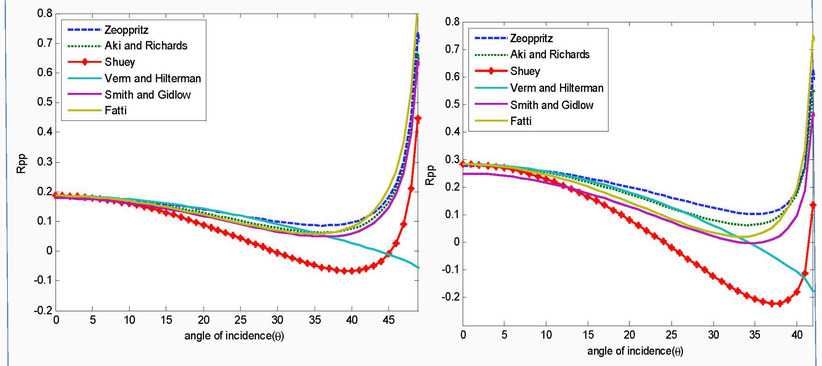

FIG. 2. Illustrate the reflection coefficients (Rpp) for different approximations using models 3 and 4 in Table 1.

Effect of $\gamma = VS/VP$ on forward modeling

The γ parameter (the S-wave velocity to P-wave velocity ratio) is a part of all approximation. So, we consider the effect of this parameter in forward modeling. To see this effect the reflection coefficient are calculated for different value of γ.

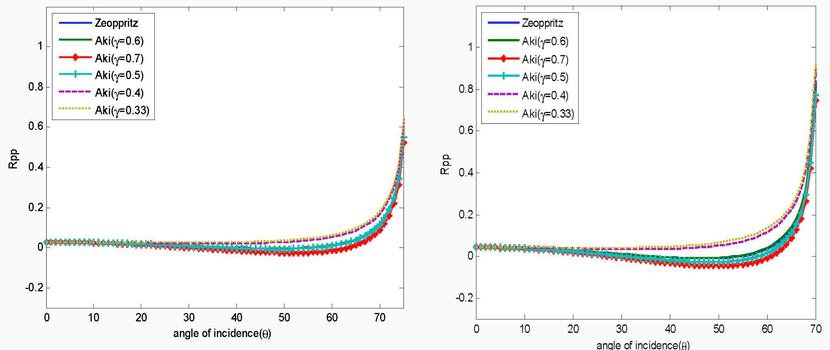

Fig. 3. Illustrate the effect of γ on forward model using models 1 and 2 for $\gamma = 0.6$, $\gamma = 033$, $\gamma = 0.4, \gamma = 0.5$, and $\gamma = 07$.

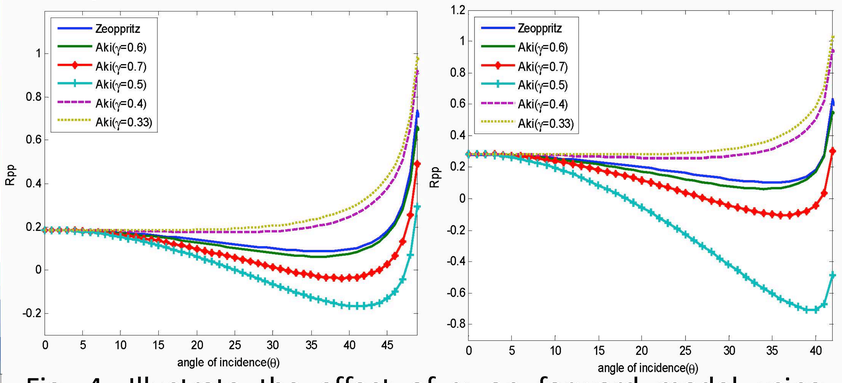

Fig. 4. Illustrate the effect of γ on forward model using models 3 and 4 for $\gamma = 0.6$, $\gamma = 033$, $\gamma = 0.4, \gamma = 0.5$, and $\gamma = 07$.

Conclusions

The exact solution of the Zoeppritz equations and the linear approximations are investigated. The reflection coefficient for the various approximations are calculated using four models which have small and larger layer contrasts. There are the larger the deviation is from the exact solution for the larger the angle of incidence (or the larger the layer contrasts). These deviation can be reasons to wrong results for inversion. In addition in this work the effect of γ on the forward modeling are investigated. When the contrast between the layer model parameter is increased, the parameter γ has more influence on forward modeling. Therefore, the act of actual value of velocities can reduce the effects of γ on forward modeling.

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