Extending spherical PP wave Class 2 AVO computations to larger depths

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ABSTRACT

In previous work we have computed spherical wave AVO responses for a maximum depth of 2000 m. A significant difference between spherical wave responses and plane wave comparisons near the critical angle for AVO Classes 1 and 2 had been observed. We have extended spherical PP wave Class 2 computations to 4000 m and 8000 m depth. At 8000 m depth the difference is small and probably negligible in practical situations.

INTRODUCTION

When isotropic spherical wave AVO responses were presented in previous reports (Haase and Ursenbach, 2004a and 2004b) we gave results for AVO Classes 1 through 4 but only for depths of 500 m, 1000 m and 2000 m. Recently the question came up as to what the spherical wave AVO behavior at larger depths would be, with an emphasis on Class 2 P-wave responses. We have repeated the Class 2 computations for additional depths of 4000 m and 8000 m. The results are presented in this report. Similar to AVO Class1, there are critical angles for spherical wave Class 2 responses and the main departures from plain wave comparisons are observed near the critical P-wave angle. Unique to our Class 2 example is a zero response at zero degrees of incidence angle (normal incidence). Even at 2000 m depth there are significant differences between spherical wave and plane wave Class 2 PP responses near the critical angle. At what depth levels are these differences negligible?

SOMMERFELD/WEYL INTEGRAL COMPUTATIONS

The starting point for our expanded depth computations is the numerical integration algorithm employed in previous work. In order to keep wrap around under control the trace length must be doubled with every doubling in depth, which means doubling the number of frequency points. The computing time is more than doubled because of an increased number of steps in the numerical integration also. Table 1 lists the layer parameters we have used for all Class 2 AVO computations. Figure 1 shows the resulting Class 2 AVO curves for 4000 m and 8000 m depth, the previous result for 2000 m depth and a plane wave comparison. The response ripples beyond the critical point are decreasing with depth. They are caused by the 5/15-80\100 Hz Ormsby wavelet utilized. Increasing the bandwidth and increasing the smoothness of the amplitude spectrum would also decrease these response ripples. Even though the 8000m response is still distinguishable from the plane wave response in this model study, in a real data situation this small difference could be expected to “hide” under the noise floor.

Table 1. Layer Parameters.

Class	α_1/[m/s]	β_1/[m/s]	ρ_1/[kg/m^3]	α_2/[m/s]	β_2/[m/s]	ρ_2/[kg/m^3]
1	2000	879.88	2400	2933.33	1882.29	2000
2	2000	879.88	2400	2400	1540.05	2000
3	2000	879.88	2400	1963.64	1260.04	2000
4	2000	1000	2400	1598.77	654.32	2456.43

SPHERICAL WAVE ZOEPPRITZ EXPLORER COMPUTATIONS

The underlying approach here is to change the order of integration with the Sommerfeld integral, prescribe a suitable wavelet and do an analytical inverse Fourier transform. This amounts to a computation of weighting functions for the remaining integration over the horizontal slowness *p*. With increasing depths these weights are narrower and narrower which results in a decrease of computing time. This trend is the opposite of what is observed previously with numerical inverse Fourier transforms. Figure 2 shows the spherical wave Zoeppritz explorer result for Class 2 AVO. Because a Rayleigh wavelet is employed here, which has a smoother amplitude spectrum than the Ormsby wavelet utilized above, there are fewer or no response ripples. The general trend of depth dependence is the same as obtained under the previous heading, thereby validating those results.

CONCLUSIONS

Class 2 PP wave AVO responses have been computed by the Sommerfeld/Weyl integral for 4000 m and 8000 m depths and are validated by a different method. With increasing depths the spherical wave AVO response approaches the plane wave comparison more and more. At 8000 m depth the difference is so small as to likely be under the noise floor for practical situations.

REFERENCES

Haase, A.B., and Ursenbach, C.P., 2004a, Spherical wave AVO-modelling in elastic isotropic media: CREWES Research Report, **16**.

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ACKNOWLEDGEMENTS

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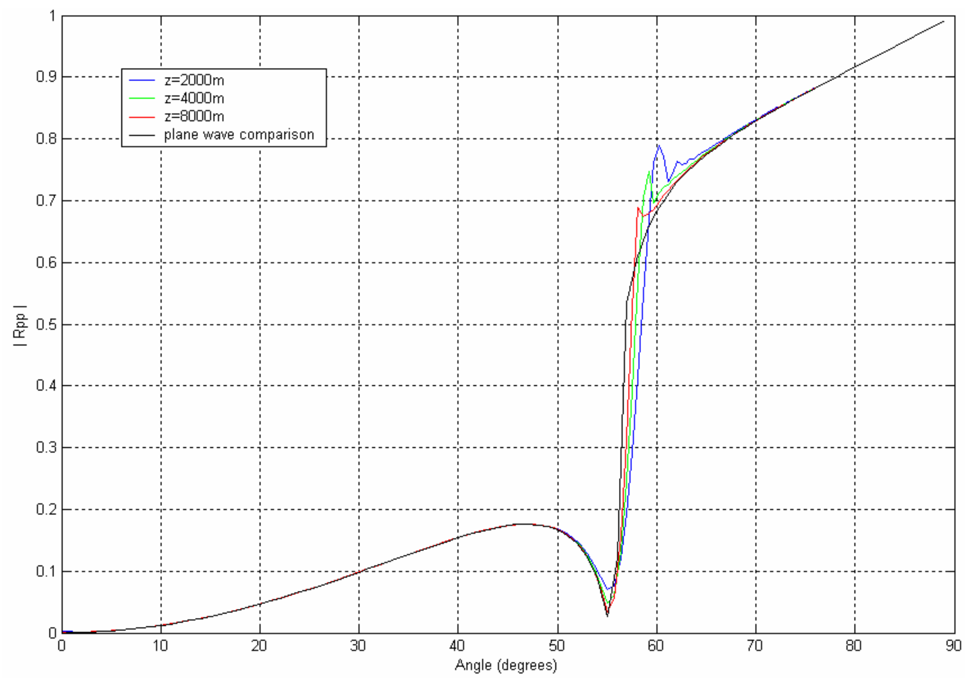
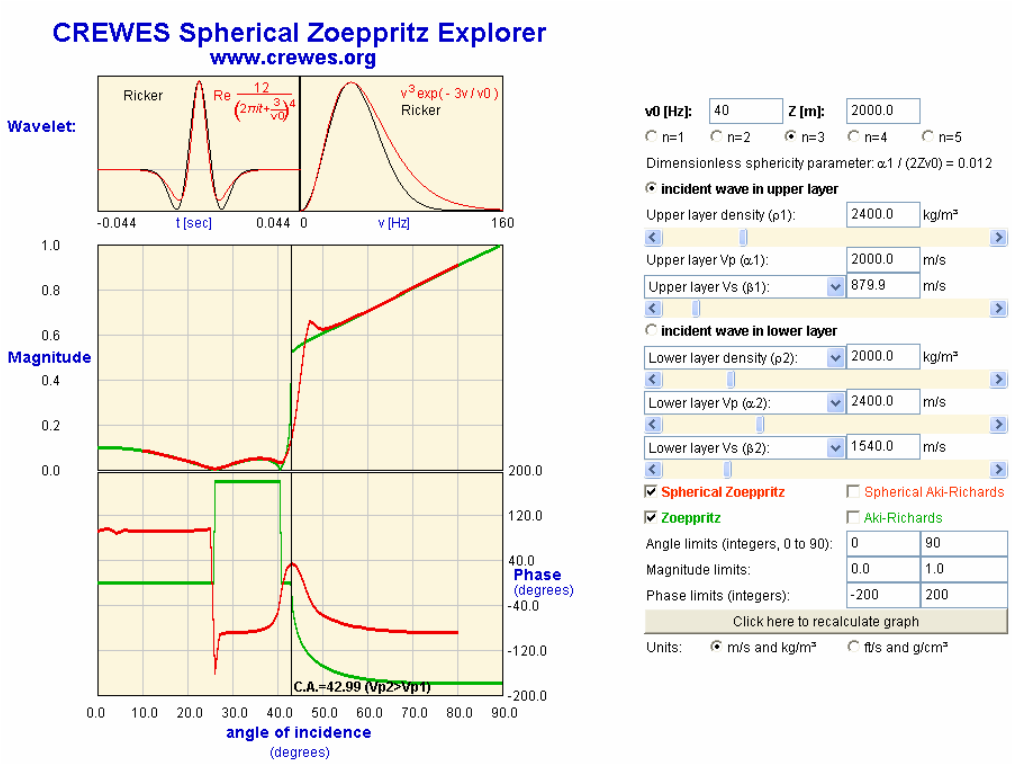
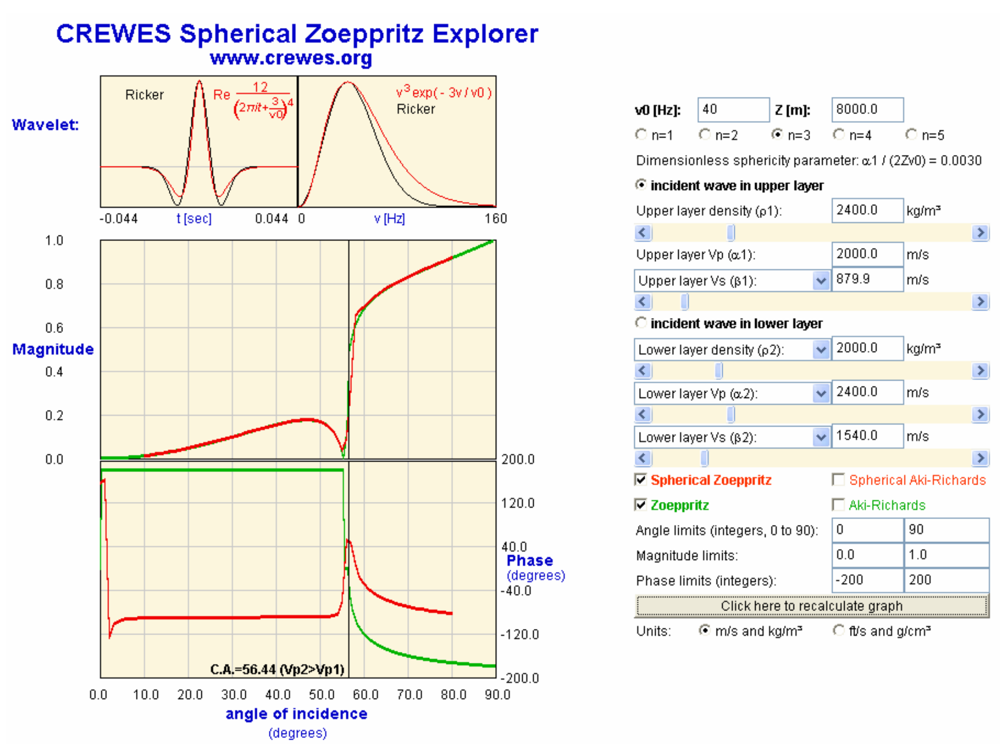


FIG. 1. AVO Class 2 spherical wave PP reflection coefficient.



a)



b)

FIG. 2: Spherical-wave reflection coefficients calculated for the Rayleigh wavelet (n = 4 and f0 = 40 Hz) and for the same earth parameters as in Figure 1. a) 2000 m. b) 8000 m.