Comparison of ray and full-wave synthetic seismograms of reflected SH waves in attenuating media

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The study of ray synthetic seismograms of reflected SH waves in attenuative media is a continuation of the work of Pšenčík et al. (2022) who applied the weak attenuation concept (WAC) to SH wave reflection/transmission (R/T) coefficients in the isotropic medium. The WAC is a perturbation technique, in which the attenuation is considered as a perturbation of the reference elastic state. Here we compare ray synthetic seismograms with WAC with full wave synthetic seismograms considered as an exact reference. The procedure is based on the Fourier and Chebyshev pseudospectral (PS) methods (Carcione, 2014).

For the tests, we use the seismograms of an SH wave reflected at an interface separating two homogeneous, isotropic elastic and anelastic half-spaces. The properties of the half-spaces (SH wave velocities, densities) are selected so that critical incidence in the reference elastic case is included, but Brewster angle is avoided in order to keep the models as simple as possible. The source and array of receivers are positioned at the same depth above the reflector. Dense step between receivers allows good mapping of the influence of the reflection coefficient on amplitude and phase of reflected waves. Three models of attenuation are used: the first model has both half-spaces elastic – this helps to evaluate general, not tied to the implementation of WAC, differences between ray and PS methods results. In the second model, first half-space is elastic and second anelastic. This model provides benchmark for the case where effects of attenuation are limited to the effects on the reflection coefficient. In the third model, both layers are anelastic, which allows to test the influence of the WAC during the propagation within the layer as well. As an example, the seismograms computed for the third model are shown in Figure 1. To facilitate comparison of results in each case, we computed maximum spectral amplitudes of computed seismograms. As an example, Figure 2 shows maximum spectral amplitudes for the model with both half-spaces anelastic.

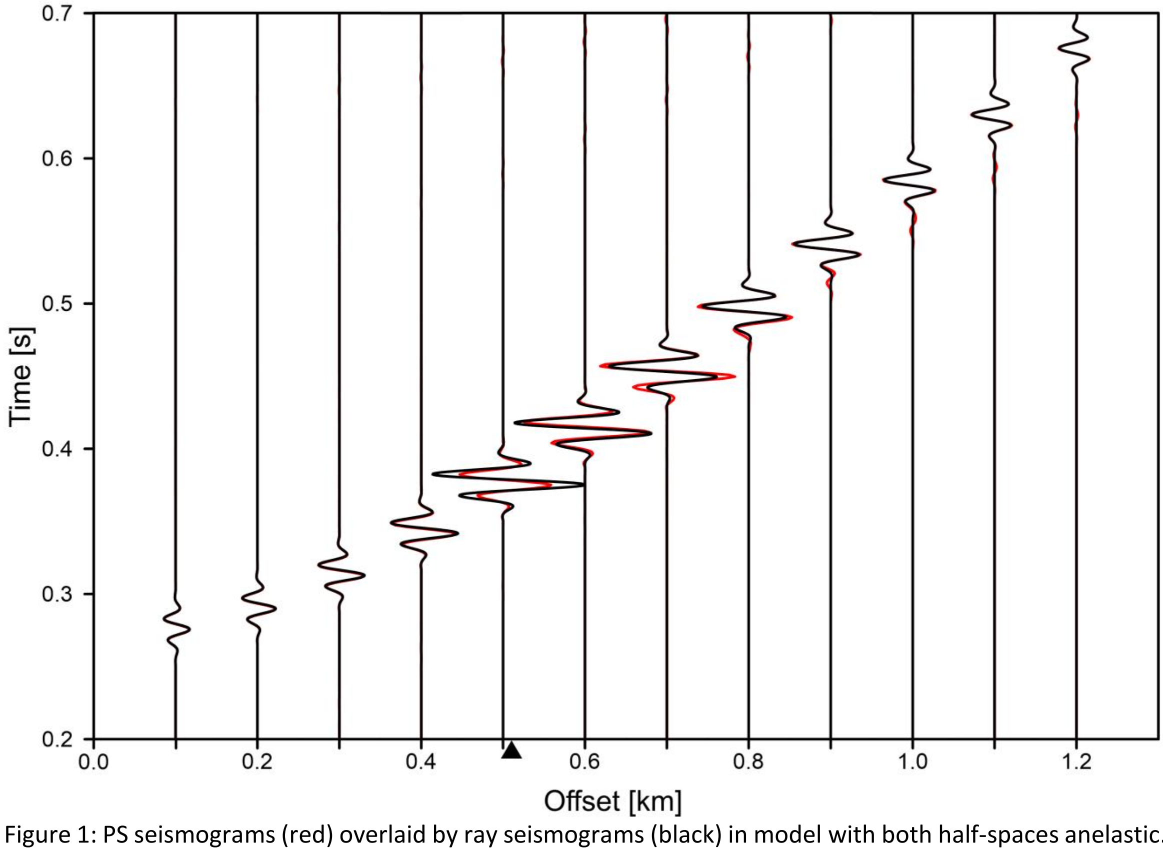

Figure 1: PS seismograms (red) overlaid by ray seismograms (black) in model with both half-spaces anelastic. Red arrival preceding the reflection behind the critical point (black triangle) is the head wave. Later red arrivals are numerical errors of the PS method.

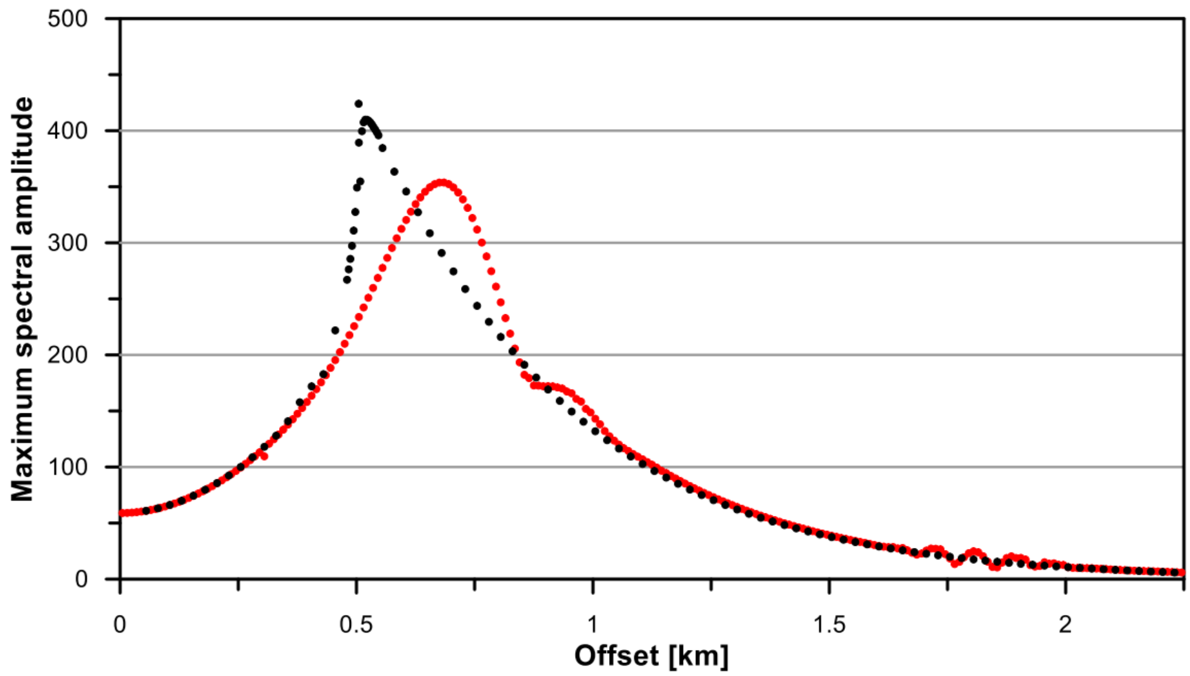

Figure 2: Maximum spectral amplitudes for model with both half-spaces anelastic calculated with the PS method (red) and by the ray method (black).

Results computed for the model with both half-spaces elastic show that outside the critical region ray results fit well the PS results. Differences in the critical region are caused by the ray method, which does not work properly in this region because it does not include head waves. Introduction of the attenuation effects on interface between half-spaces results in a small decrease of amplitudes in the vicinity of the critical angle for both methods. It does not increase the magnitude of differences between methods. Results computed for the model with both half-spaces anelastic, in which waves propagate inside attenuative layers, show that the decrease of amplitudes due to the attenuation effects at the interface are small in comparison to the decrease of amplitudes due to attenuation within the layers. Tests showed that outside the critical region the ray method with WAC yields results of satisfactory accuracy.

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