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Why some numerical schemes loose their accuracy with increasing P-wave to S-wave speed ratio?

Peter Moczo (1,2), Jozef Kristek (1,2), Martin Galis (1,2), and Emmanuel Chaljub (3)

(1) Faculty of Mathematics, Physics and Informatics, Comenius University, Department of Astronomy, Physics of the Earth & Meteorology, Bratislava, Slovakia (moczo@fmph.uniba.sk, +421 2 6542 5982), (2) Geophysical Institute, Slovak Academy of Sciences, Bratislava, Slovakia, (3) ISTerre UJF, Grenoble, France

It is well known that surface sediments and especially sedimentary basins and valleys can significantly affect the earthquake motion and cause site effects of earthquakes that are in most cases responsible for the most severe damages in the populated areas. The surface sediments can also considerably affect the teleseismic motion.

The surface sediments pose considerable challenge for numerical modeling of earthquake ground motion. The methods have to properly account for the geometry of the sediment-rock interface, realistic attenuation and realistic VP/VS ratio. The latter can attain large values. VP/VS about 5 in the typical deep Alpine valley beneath Grenoble, France, 7.5 in the Mygdonian basin near Thessaloniki, Greece, and more than 10 in the sediments beneath Ciudad de México are good representative examples.

In our previous study we numerically compared 12 numerical schemes based on the finite-difference, finite-element, spectral-element and discontinuous-Galerkin methods. All schemes were 2nd-order in time. 7 schemes were 2nd-order, 6 schemes were 4th-order in space. We investigated the (full) local error in one time step to quantify accuracy of the schemes as a function of the VP/VS ratio. We found considerable differences between schemes and also quite surprising results.

Here we systematically theoretically analyze and interpret the numerical results. The analysis led us to explanation why some numerical schemes loose their accuracy with increasing P-wave to S-wave speed ratio. The explanation has a direct impact on the design and development of the numerical schemes.