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A stable arbitrarily discontinuous staggered grid for FD modeling of seismic motion

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Recent E2VP-Cashima numerical modeling of earthquake motion in the Mygdonian basin, Greece, included 5 km x 15 km sediments with maximum thickness 400 m, minimum VS=200 m/s, VP/VS=7.5, and VS=2600 m/s in the bedrock. Consequently, the finite-difference (FD) modeling of 30 s time window in the frequency range [0.3, 6] Hz was heavily depending on the computational efficiency of the applied finite-difference scheme. The key aspect of the efficiency was the use of a discontinuous staggered grid for the 4th-order velocity-stress scheme.

We present an algorithm of the spatial discontinuous staggered grid. The ratio between the grid spacings of the coarser and finer grids can be an arbitrary odd number. We numerically tested ratios up to 25.

Relatively many algorithms for different kinds of discontinuous grids have been developed and published. They focused on the problem how to interpolate values at missing grid positions in order to update wavefield in the finer grid. As we found out, the interpolation, in fact, neither poses a real problem nor solves the key aspect of a contact between the finer and coarser grids. As far as we know the other algorithms did not address this aspect and consequently and inevitably had problems with stability.

The key aspect of a contact between the finer and coarser grids is what values at grid positions of a finer grid should enter the update in the coarser grid. We solve this aspect by the application of the Lanczos downsampling filter. Our algorithm is sufficiently accurate and stable.