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The finite-difference modelling of seismic waves in poroelastic medium: A new efficient and accurate discrete representation of a strong discontinuous and smooth material heterogeneity

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Moczo et al. (2002, 2014), Kristek & Moczo (2003) and Kristek et al. (2017) developed the discrete representation of a strong discontinuous and smooth material heterogeneity in the elastic and viscoelastic media suitable for the finite-difference modelling of seismic wave propagation and earthquake ground motion. The representation is capable of sub-cell resolution and "sensing" an arbitrary shape and position of the interface in the grid. Extensive tests in canonical and complex realistic models confirmed accuracy and computational efficiency of the representation. With the proper discrete representation of material heterogeneity the most advanced finite-difference schemes can be more efficient in case of local surface sedimentary structures than the spectral-element and discontinuous-Galerkin methods (e.g., Chaljub et al. 2010, 2015; Maufroy et al. 2015).

Is such a discrete representation possible also in the considerably mathematically and physically more complex poroelastic medium with larger number and more complex constitutive and governing equations? Yes, it is possible.

We have developed a new discrete representation of the discontinuous and continuous material heterogeneity of the poroelastic medium. In our representation the stiffness matrix of the averaged medium has the same structure as the stiffness matrix for a smoothly heterogeneous medium but sufficiently accurately approximates boundary conditions at the interface. The same structure means that the number of algebraic operations in calculating stress and pressure is the same as in the smoothly heterogeneous poroelastic medium.

We demonstrate the accuracy and the sub-cell resolution using a set of canonical configurations. We compare our seismograms with those calculated by the exact method developed by Diaz & Ezziani (2008). We also compare our seismograms with those obtained with an independent numerical method for a structurally complex model.