THE FINITE-DIFFERENCE MODELLING: WHERE IS IT AND WHAT'S NEXT?

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The finite-difference (FD) method is recently one of three most important and most used numerical methods for modelling seismic wave propagation and earthquake motion. While it is clearly dominant in the seismic exploration, it competes with the spectral-element (SE) and discontinuous Galerkin (DG) methods in the earthquake seismology, being most used for modelling earthquake motion in local small-scale surface sedimentary structures. Very recently, it is to be compared with a new powerful method – the distributional FD method.

The FD method in seismology has been continuously developing for almost 60 years. Surprisingly (or obviously?), the development was neither straightforward nor truly always logical in terms of consistency with mathematics and physics. Likely because the method seems to be very or relatively simple compared to the other methods. Clearly, one of the most important aspects of any numerical method is the implementation of continuous and mainly discontinuous heterogeneities of the medium. Several times in the history of the method, developers of FD methodology and mainly users of FD codes assumed that the problem was satisfactorily or even fully solved by those-times modern FD schemes. Especially the so-called heterogeneous schemes.

In our contribution we demonstrate that it was not always the case. Based on our very recent and surprising findings we explain consequences of implementation of boundary conditions at a material interface, and spatial discretization of a medium and wavefield for heterogeneous FD schemes. We outline what must be still developed in order to find a FD scheme consistent with mathematics and physics.