Accurate seabed modelling using finite difference methods

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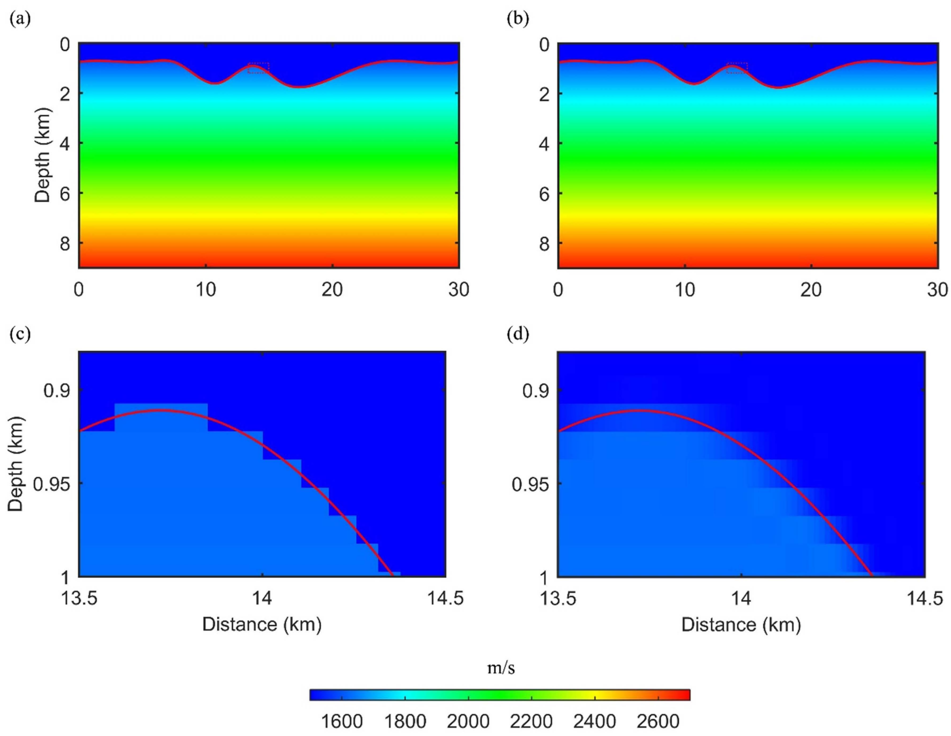
Finite difference is the most widely used method for seismic wavefield modelling. However, most finite-difference implementations discretise the Earth model over a fixed grid interval. This can lead to irregular model geometries being represented by ‘staircase’ discretisations, and potentially causes mispositioning of interfaces within the media. This misrepresentation is a major disadvantage to finite difference methods, especially if there exist strong and sharp contrasts in the physical properties along an interface. The discretisation of undulated seabed bathymetry is a common example of such misrepresentation of the physical properties in finite-difference grids, as the seabed is often a particularly sharp interface owing to the rapid and considerable change in material properties between fluid seawater and solid rock. There are two issues typically involved with seabed modelling using finite difference methods: firstly, the travel times of reflections from the sea bottom are inaccurate as a consequence of its spatial mispositioning; secondly, artificial diffractions are generated by the staircase representation of dipping seabed bathymetry. In this paper, we propose a new method that provides a solution to these two issues by positioning sharp interfaces at fractional grid locations. To achieve this, the velocity model is first sampled in a model grid that allows the centre of the seabed to be positioned at grid points, before being interpolated vertically onto a regular modelling grid using the windowed sinc function. This procedure allows for undulated seabed bathymetry to be represented with improved accuracy during modelling. Numerical tests demonstrate that this method generates reflections with accurate travel times and effectively suppresses artificial diffractions.

Keywords: finite difference, seabed bathymetry, integer grid, fractional grid, staircase, sinc interpolation



An acoustic velocity model containing an undulating seabed, sampled using the (a) Integral Grid Model and (b) Fractional Grid Model methods. (c) and (d) are enlarged views of the areas outlined by the red dotted squares in (a) and (b), respectively. The red curve in each panel indicates the true position of the seabed.