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Efficient discretization in finite difference method

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Finite difference method (FDM) is a plausible and simple method for solving partial differential equations. The standard practice is to use an orthogonal discretization to form algebraic approximate formulations of the derivatives of the unknown function and a grid, much like raster maps, to represent the properties of the function domain. For example, for the solution of the groundwater flow equation, a raster map is required for the characterization of the discretization cells (flow cell, no-flow cell, boundary cell, etc.), and two raster maps are required for the hydraulic conductivity and the storage coefficient. Unfortunately, this simple approach to describe the topology comes along with the known disadvantages of the FDM (rough representation of the geometry of the boundaries, wasted computational resources in the unavoidable expansion of the grid refinement in all cells of the same column and row, etc.). To overcome these disadvantages, Hunt has suggested an alternative approach to describe the topology, the use of an array of neighbours. This limits the need for discretization nodes only for the representation of the boundary conditions and the flow domain. Furthermore, the geometry of the boundaries is described more accurately using a vector representation. Most importantly, graded meshes can be employed, which are capable of restricting grid refinement only in the areas of interest (e.g. regions where hydraulic head varies rapidly, locations of pumping wells, etc.). In this study, we test the Hunt approach against MODFLOW, a well established finite difference model, and the Finite Volume Method with Simplified Integration (FVMSI). The results of this comparison are examined and critically discussed.