Single Porosity Model: Exploring the Spatial Resolution Limits in Complex Urban Patterns

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Urban floods pose a significant threat to human development due to their increasing frequency and intensity, often with limited reaction times for populations. The Porosity Nonlinear Shallow Water Equations (PNSWE) offer computational efficiency in modeling urban floods by employing coarse grids and representing topographic features through porosity, while compromising results accuracy. In the Single Porosity (SP) model, porosity accounts for the reduced storage section due to floodplain obstacles, incorporating a porosity gradient term to the momentum equations. However, little is known about the impact of grid size on accuracy, especially when using a porosity defined at the cell-level. In this study, we use the SP model with a cell-level porosity, while gradually increasing grid resolution from fine- to macro-scale. Comparative analysis against a fine-scale classical approach provides insights into the effect of grid size on accuracy, considering the typical street-width of the urban area for generalizability. Errors in flow depths, velocities, discharges, and flood risks are reported as functions of cell size to provide insights for appropriate mesh size selection. Results demonstrate that at the meso-scale, where cell size approximates the typical street-width, computational time is significantly reduced and main flow paths and hazards are captured, providing a good trade-off between accuracy and CPU time. At such a scale, porosity models at the cell-level prove effective in inducing flow directionality and capturing flow properties by means of the porosity gradient, enhancing real-time decision-making in early-warning systems. These findings underscore the importance of porosity models in rapidly assessing flow properties during flood events for informed decision-making.

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