The influence of a grid structure on hydraulic river modelling outcomes of schematised river meanders

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Abstract

Flow simulations in rivers are typically carried out using spatially-averaged quantities, which are affected by choice of grid structure. To isolate these effects, we set up schematised river meanders with a flat bed in the transverse flow direction. We considered curvilinear and triangular grids with a high, medium and low resolution for cases where floodplains are excluded. Next, curvilinear, triangular and hybrid (combination of curvilinear and triangular cells) grids with a high and medium resolution are applied in schematised rivers where floodplains are present. The analysis showed that lower depth-averaged flow velocities and higher water depths are simulated with coarser grids. The numerical effects by the coarser grids are substantially larger in cases with distinct flow changes, such as in sharper river bends, and areas with high discharges per unit width.

Keywords: Grid resolution, Grid shape, Numerical diffusion, false diffusion, Two-dimensional depth-averaged model.

Methods

The objective of this study is to understand under which conditions effects by grid generation choices affect hydraulic river modelling outcomes in schematised meander bends. Four schematised river meanders are set-up to isolate numerical effects, which can be differentiated by a mild or sharp bend and the presence/absence of floodplains (Fig. 1 and Fig. 2). Simulations are performed in in D-Flow Flexible mesh, which is a two-dimensional (2D) depth-averaged model.

Curvilinear and triangular grids are considered with three different grid resolutions (high, medium and low) in the cases without floodplains:

- 20, 10 and 5 curvilinear grid cells in respectively the transverse flow direction; and
- 8, 4 and 3 triangular grid cells in respectively the transverse flow direction.

In the cases with floodplains, curvilinear and triangular grids, as well as hybrid (Fig. 3) grids, are used with only a high and medium grid resolution

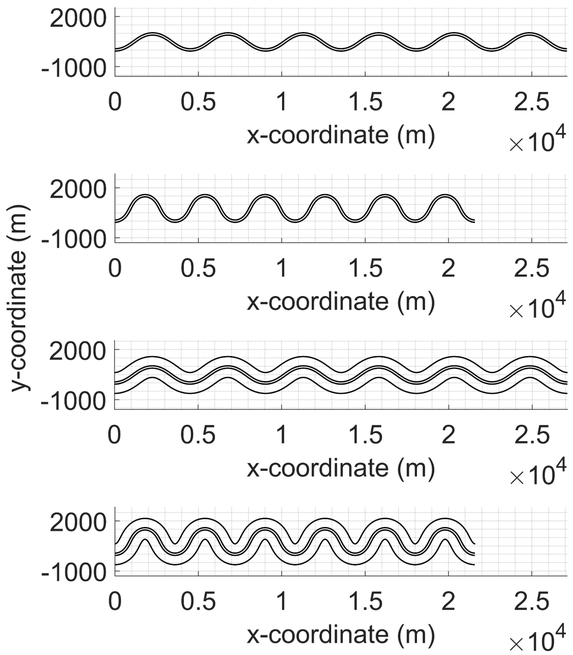

Fig. 1: a top-view of a section of the four schematised rivers

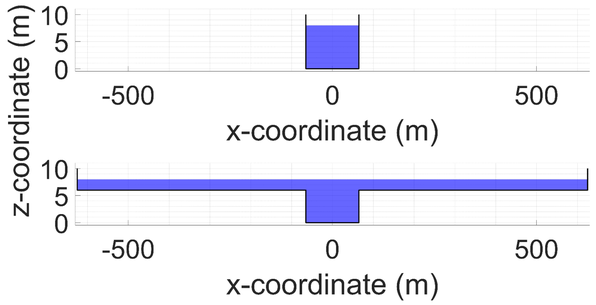

Fig. 2: the applied cross-sections in the absence/presence of floodplains

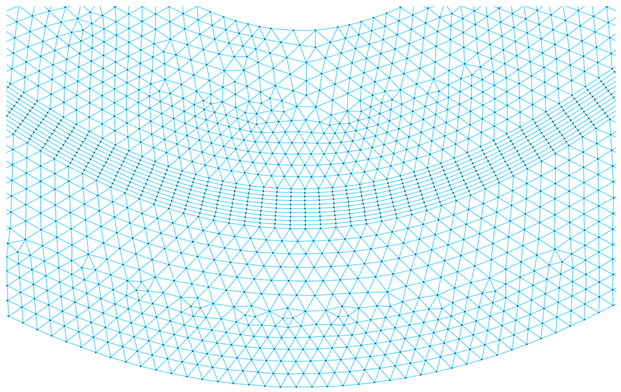

Fig. 3: An example of one of the considered hybrid grids

Results

With coarser grids we found:

- lower depth-averaged flow velocities; and
- higher water depths.

For the main channel cases we found:

- Larger differences between grids in sharper river bends; and
- Larger differences between grids at higher discharges; and
- Less numerical effects with curvilinear grids than with triangular grids.

For the floodplain cases we found:

- negligible differences in water level; and
- relatively less deviations in depth-averaged flow velocity differences throughout the spatial domain.

Conclusions

Numerical effects:

- become larger at higher discharges and hence higher depth-averaged flow velocities; and
- become larger under circumstances with rapid flow changes; and
- are proportional to the discharge per unit width.

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