Changes in dam break hydrodynamic modelling practice?

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Objectives

- Demonstrate different approaches for dam break modelling
- Discuss advances in 2D modelling: special focus on flexible mesh schematisation
- Examine the application of GPU technology in hydrodynamic modelling
Dam break modelling

Hydraulic model: Flood extent & evacuation time prediction

Development of breach failure, flow through breach and flood propagation
1D dam break modelling

- Branch network
- Cross-sections
- Dam break structure
2D dam break modelling

Dynamic topography
“Deforming” over period of dam break
2D modelling – Different numerical solutions

Square network of elements
- Same element size
- Finite difference code

Rectangular grid

Flexible mesh

Triangular & quadrangular elements
- Varying element size
- Finite volume code

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2D modelling – Flexible mesh

△ Triangular elements

Quadrangular elements
Parallelisation – Using GPU technology

GPU – Graphics Processing Unit
CPU – Computational Processing Unit

GeForce GTX TITAN GPU card, middle of the range gaming card retails for approx. USD$1000
GPU concept

Model domain

Model sub-domain #1

Model sub-domain #2

Model sub-domain #3

Model sub-domain #4
Our study

• Dam for regulated river water supply
• Research study, no real event
• Comparison of different hydraulic modelling/computational approaches and simulation speed
Our study

Two 1D models
- Energy equation model
- NWS DAMBRK model

Three 2D models
- Rectangular grid model
- Square mesh model
- Flexible mesh model
2D models

Grid/Square mesh

371,882 elements

Flexible mesh

66,539 elements

More detail: Dam crest, areas of flow changes

Flow direction

Less detail: Lake reservoir
GPU runs

Models run on GPU:

• Square mesh 2D model
• Flexible mesh 2D model
Study results – Discharge hydrograph

- Similar shapes of discharge hydrographs
- Variations in peak discharge and recession curve behaviour
## Study results – Computational speeds

<table>
<thead>
<tr>
<th>Model</th>
<th>Computational code</th>
<th>Computational time (h)</th>
<th>Factor of speed increase on GPU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CPU</td>
<td>GPU</td>
</tr>
<tr>
<td>2D grid</td>
<td>Finite difference</td>
<td>21.3</td>
<td>-</td>
</tr>
<tr>
<td>2D square mesh</td>
<td>Finite volume</td>
<td>148.6</td>
<td>21.5</td>
</tr>
<tr>
<td>2D flexible mesh</td>
<td>Finite volume</td>
<td>47.3</td>
<td>6.6</td>
</tr>
</tbody>
</table>
Conclusions

• Different peak flow estimates for different modelling approaches
• Differences between 2D models due to different mesh/grid set ups, with flexible mesh better representing complex geometries
• Flexible mesh model able to balance computational speed against accuracy
• The use of GPU can significantly decrease the simulation time
Thank you for your attention

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