Rapid and Accurate Stormwater Drainage Assessments Using GPU Technology

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Brisbane, Australia
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Presentation Overview
Urban Direct Rainfall Modelling (1D +2D)

1. TUFLOW HPC
   • What it is?

2. Case study example
   • Where?
   • How the modelling was done?

3. Modelling advice
   • What matters
TUFCLOW HPC (Heavily Parallelised Compute)
New to TUFCLOW 2017

1. Alternative fixed grid 2D solver to TUFCLOW Classic
2. TUFCLOW GPU Mark II
   - Improved 1st Order solution scheme from TUFCLOW GPU
   - New 2nd Order solution (the default)
   - Change in cell schematisation to utilise cell sides
   - All 1D/2D linking functionality (HX and SX)
   - All 1D functionality
   - Unconditionally stable
3. Runs on CPUs and Nvidia GPU devices
Study Overview
- Cassowary Coast Regional Council (CCRC)
- Hydraulic assessment of urban drainage infrastructure for 10 major towns

Study Objectives
- Review of existing network capacity / performance
- Development of a future infrastructure upgrade plan
Urban Stormwater Modelling Data Inputs

What inputs go into an urban stormwater 1D / 2D direct rainfall hydraulic model?
Urban Stormwater Modelling Data Inputs
Spatially Varying Landuse and Soil Data

- Bed resistance
  - Depth varying
  - Log law
- Perviousness
  - %
- Loss options
  - Rainfall excess
  - IL / CL infiltration
  - Green Ampt infiltration
  - Horton infiltration
Urban Stormwater Modelling Data Inputs

Topography Data

- LIDAR
- Ground Survey
- Bathymetric survey / cross-sections
- Design drawings (12D, LandXML)
Urban Stormwater Modelling Data Inputs

Stormwater Network

- Inlets
- Manholes or junctions
- Stormwater pipes

**New “Road Crossfall” option to improve flow capture at pits**
Urban Stormwater Modelling Data Inputs

Stormwater Network

- Inlets
- Manholes or junctions
- Stormwater pipes
- Gates, Spillways, Weirs, Backflow control devices

Variety of energy loss options

Fixed (optional) = QUDEM compatible
Engelund method (default)

1) Expansion / contraction of flow
2) Changes in pipe size
3) Changes in angle at junctions
4) Change in elevation at junctions
Urban Stormwater Modelling Data Inputs
Hydrologic Input Options

Hydrologic Model inflows
RORB, URBS, WBMN, XPRAFTS or user defined

or

Direct Rainfall
(used in CCRC study)
What is rainfall on grid?

Rainfall is applied to every 2D cell.

The hydraulic model routes flows (2D SWE)

Avoids potential errors associated with hydrologic sub-catchment delineation

Urban Stormwater Modelling Data Inputs
Direct Rainfall Example

Infiltration = IL / CL
Event Duration = 12h
Rainfall Total = 486mm
What is rainfall on grid?
Rainfall is applied to every 2D cell.
The hydraulic model routes flows (2D SWE)
Avoids potential errors associated with hydrologic sub-catchment delineation

Excellent representation of key physical processes
1) Rainfall
2) Hydrologic losses (infiltration)
3) Runoff
4) Flow capture by the stormwater network
5) Energy loss within the underground pipe network
6) Above / below ground stormwater network interactions
Urban Stormwater Modelling Data Inputs
Direct Rainfall – 1D/2D integration

Dynamically linked 1D stormwater network and 2D overland flow model

Accurate representation of overflow into neighbouring drainage areas if stormwater network capacity is exceeded
Accurate topography data

What 2D model resolution…

How fine for urban situations?

• 20m 7,500 cells
Accurate topography data

What 2D model resolution…

How fine for urban situations?

- 20m  7,500 cells
- 10m  31,000 cells
Accurate topography data

**What 2D model resolution…**

How fine for urban situations?

- 20m  7,500 cells
- 10m  31,000 cells
- 5m   125,000 cells
Accurate topography data
What 2D model resolution…
How fine for urban situations?

- 20m  7,500 cells
- 10m  31,000 cells
- 5m   125,000 cells
- 2m   750,000 cells
Urban Stormwater Modelling Data
What Matters?

Accurate topography data

**What 2D model resolution…**

How fine for urban situations?

- 20m  7,500 cells
- 10m  31,000 cells
- 5m   125,000 cells
- 2m   750,000 cells
- 1m   3,100,000 cells
Accurate topography data

What 2D model resolution…

How fine for urban situations?

- 20m  7,500 cells
- 10m  31,000 cells
- 5m   125,000 cells
- 2m   750,000 cells
- 1m   3,100,000 cells
- 0.5m 12,500,000 cells
Accurate topography data
What 2D model resolution...
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• 20m  7,500 cells
Accurate topography data
What 2D model resolution…
How fine for urban situations?

- 20m  ✗  7,500 cells
- 10m  ✗  31,000 cells

10m Grid Resolution
Flood Level Difference
(m - relative to 0.5m resolution model)
Accurate topography data
What 2D model resolution…
How fine for urban situations?

- 20m  ×  7,500 cells
- 10m  ×  31,000 cells
- 5m   ×  125,000 cells

Urban Stormwater Modelling Data
What Matters?

5m Grid Resolution

Flood Level Difference
(m - relative to 0.5m resolution model)
Accurate topography data

What 2D model resolution…

How fine for urban situations?

- 20m  ×  7,500 cells
- 10m  ×  31,000 cells
- 5m   ×  125,000 cells
- 2m   ✓  750,000 cells

2m Grid Resolution

Flood Level Difference
(m - relative to 0.5m resolution model)
Accurate topography data

What 2D model resolution…

How fine for urban situations?

- 20m ✗ 7,500 cells
- 10m ✗ 31,000 cells
- 5m ✗ 125,000 cells
- 2m ✓ 750,000 cells
- 1m ✓ 3,100,000 cells
- 0.5m ✓ 12,500,000 cells

Urban Stormwater Modelling Data
What Matters?

Flood Level Difference
(m - relative to 0.5m resolution model)
**Urban Stormwater Modelling Data**

**What Matters?**

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**Solver and Hardware Options**

<table>
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<th>Classic</th>
<th>HPC</th>
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<tr>
<td>0.5m</td>
<td>≈48 days</td>
<td>18.30 hr</td>
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**CPU = 17-5960X CPU @3.00GHz**

**GPU = 2 x GeForce GTX 980**

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**Simulation Time (hrs)**

- **TUFLOW Classic (CPU Hardware)**
- **TUFLOW HPC (GPU Hardware)**

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**Graph**

- Y-axis: Simulation Time (hrs)
- X-axis: 2D Cells (1000s)
Urban Stormwater Modelling Data
What Matters?

Solver and Hardware Options

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Graph showing simulation time comparison between Classic CPU, HPC GPU, and GPU Speed-up (Times faster than CPU).
Study Outcomes

- Physical review of infrastructure condition
- Infrastructure capacity modelling (current and future climate)
- Priority infrastructure upgrade tables

General Modelling Summary

- Urban modelling is now more efficient thanks to HPC and GPU hardware
- Accurate representation of the physical urban drainage processes
- Cell size selection is an important consideration for result accuracy and realistic simulation run time
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