“Where will our knowledge take you?”

Flood Modelling Using GPU Hardware

12D Conference
Brisbane, Australia
Chris Huxley

Presentation Overview

1. **What is GPU?**
2. **How does the new GPU solver compare to the existing CPU Solver?**
3. **Example Applications**
    - High Resolution 1D/2D Urban Assessment
    - Whole of Catchment Modelling
    - Flood Forecasting
4. **Questions**

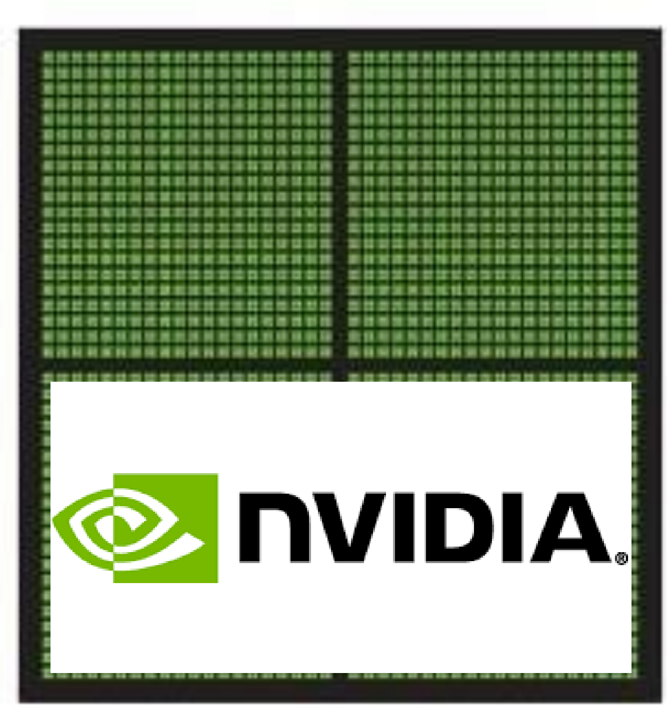
What is GPU?

1

What is GPU?
Graphics Processing Unit

Traditionally used for graphics visualisation
Now used for scientific compute too

- **Accelerated hardware development since 2000**
- **Parallel computing is used to achieve computation gains**
- **TUFLOW is NVIDIA GPU compatible (not AMD)**
- **We support multiple GPU cards**
- **10 - 100 simulation speed up compared to CPU**



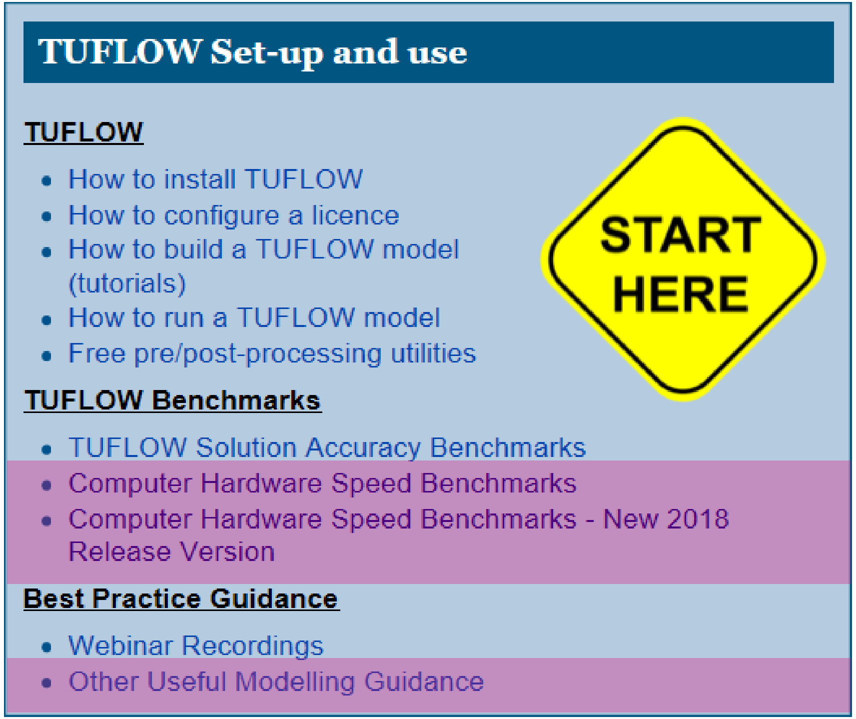
What is GPU?
Graphics Processing Unit

Are all GPU cards equal?

NO

https://wiki.tuflow.com

- Hardware benchmarking
- GPU modelling guidance


TUFLOW Set-up and use

TUFLOW

- How to install TUFLOW
- How to configure a licence
- How to build a TUFLOW model (tutorials)
- How to run a TUFLOW model
- Free pre/post-processing utilities

TUFLOW Benchmarks

- TUFLOW Solution Accuracy Benchmarks
- Computer Hardware Speed Benchmarks
- Computer Hardware Speed Benchmarks - New 2018 Release Version

Best Practice Guidance

- Webinar Recordings
- Other Useful Modelling Guidance

How does the GPU and CPU solvers compare?

2

TUFLOW HPC (GPU Module)
Solution Scheme

Explicit, Finite Volume shock capturing solution

- Better suited to parallelisation than implicit schemes (Classic)

4th order in time, Runge-Kutta integration solution

2nd Order in space the default

- Same spatial order and cell design as Classic

Adaptive timestep design

- Courant number
- Wave celerity number
- Diffusion number

defaults

$$N_u = \max\left(\frac{|u|\Delta t}{\Delta x}, \frac{|v|\Delta t}{\Delta y}\right) \leq 1.0$$

$$N_c = \max\left(\frac{\sqrt{gh}\Delta t}{\Delta x}, \frac{\sqrt{gh}\Delta t}{\Delta y}\right) \leq 1.0$$

$$N_d = \max\left(\frac{\nu_T \Delta t}{\Delta x^2}, \frac{\nu_T \Delta t}{\Delta y^2}\right) \leq 0.3$$

Unconditional stability

- Exceptionally stable >> user beware ☺

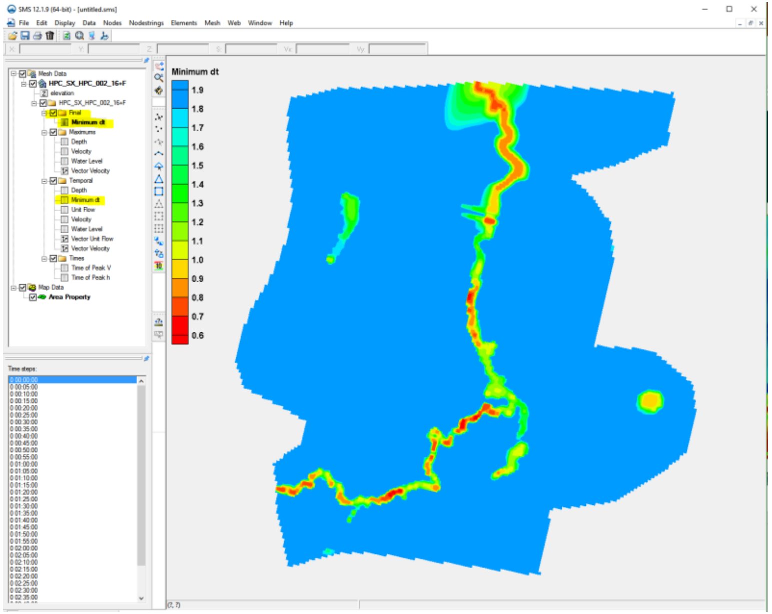
Classic vs HPC
Beware of the stability!

Classic (CPU)

- Can go unstable (as we all know!) due to matrix solution not converging
- Instabilities highlight bad data / poor model setup and force the modeller to fix models

HPC (GPU)

- VERY VERY stable and has zero mass error
- This may hide poor data or poor model set up (accidental boundary condition or topography errors)
- Use ‘dt” output with check files to review location of minimum limiting timestep



Example Applications

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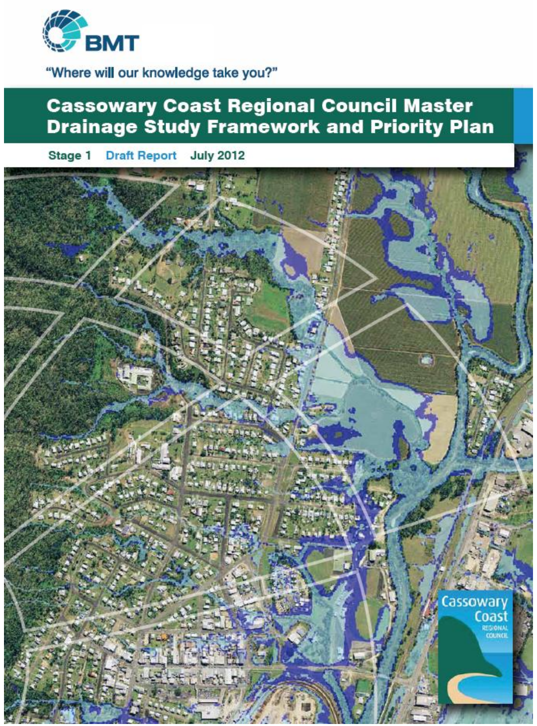
High Resolution 1D/2D Urban Assessment

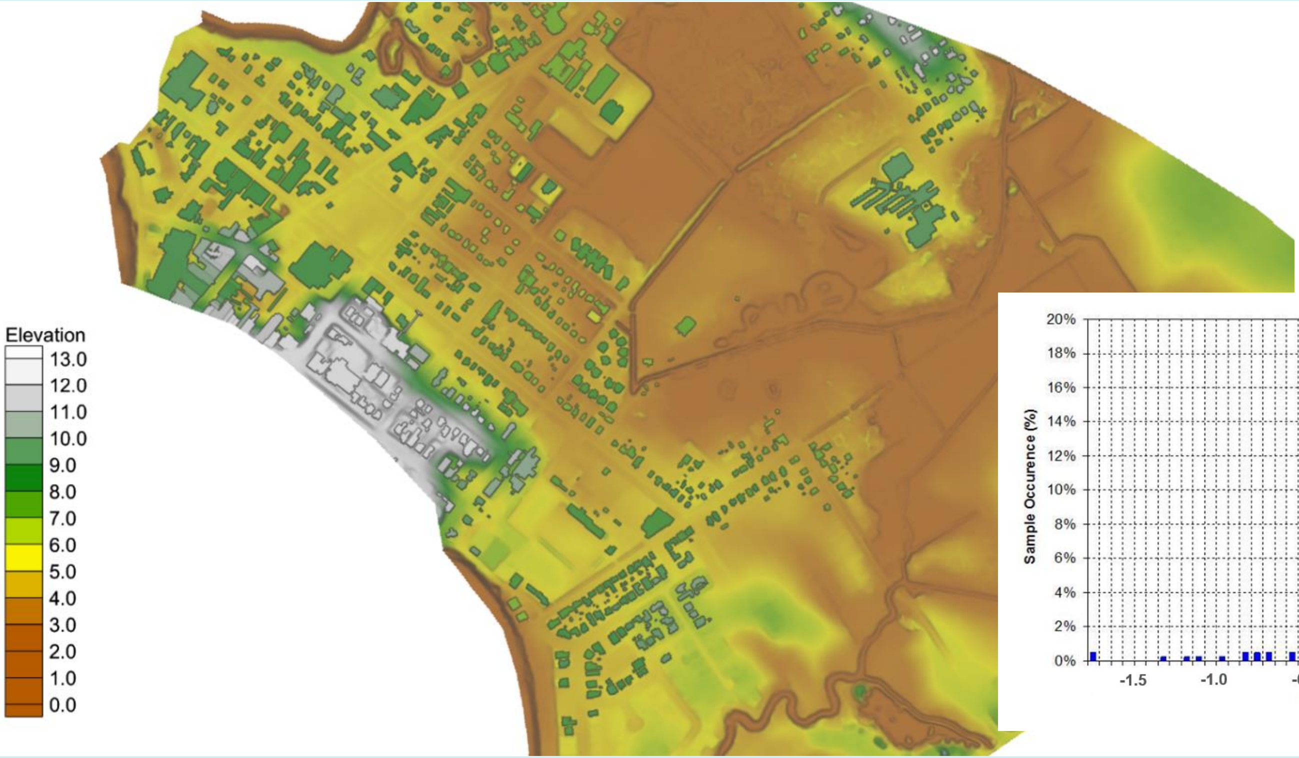
Council Master Drainage Study

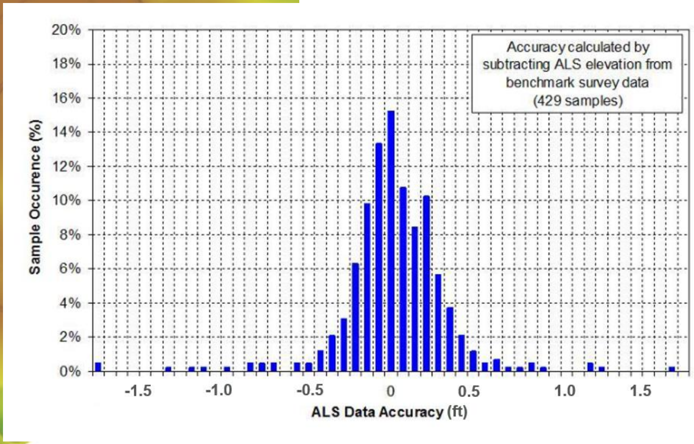


Cardwell
Innisfail CBD
Innisfail East
Innisfail Estate
Mission Beach
Mourilyan
Silkwood
South Johnston
Tully
Tully Heads / Hull Heads

High Resolution 1D/2D Urban Assessment

Topography Data

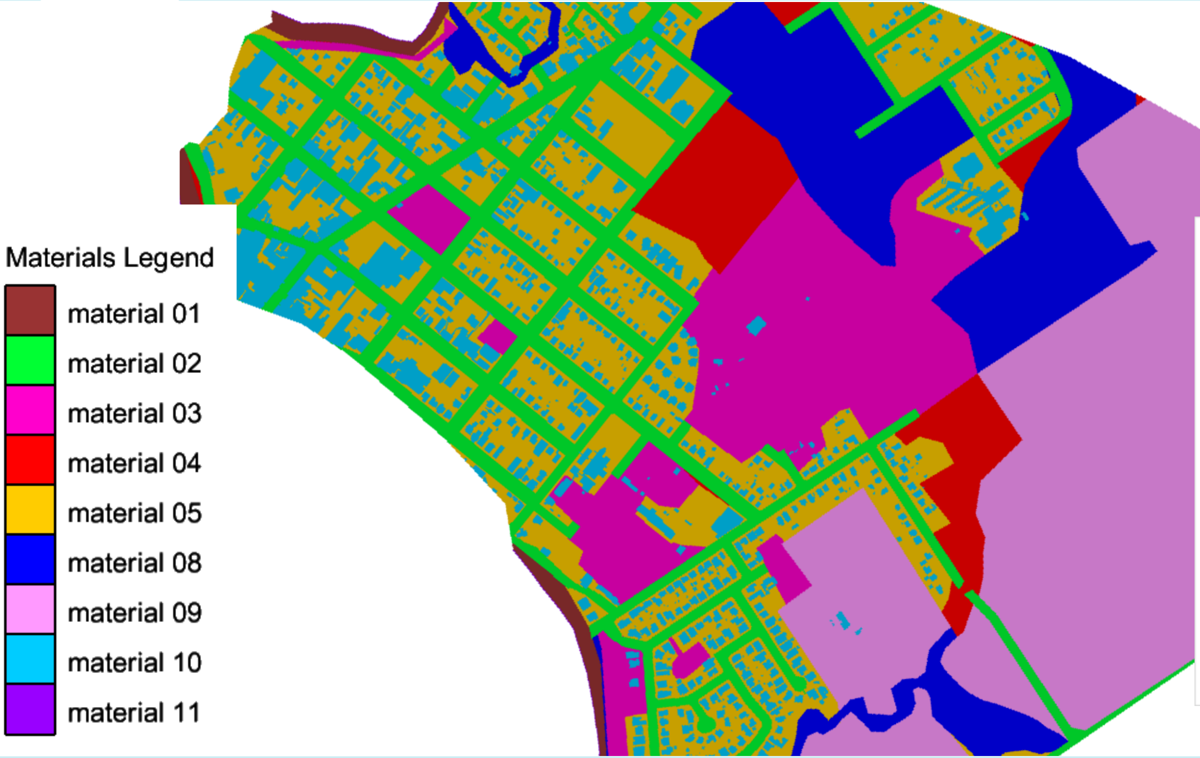


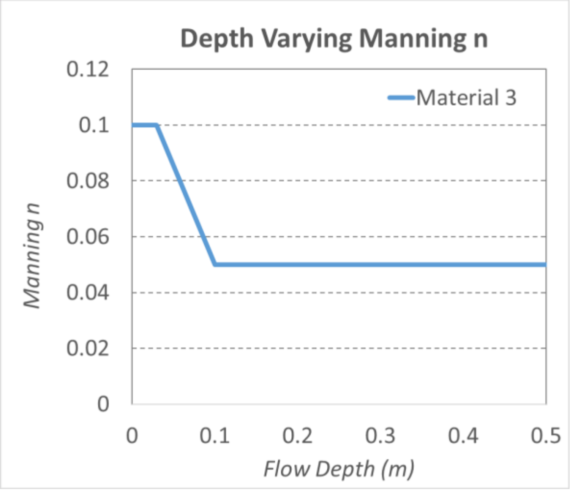


High Resolution 1D/2D Urban Assessment

Stormwater Pipe Network

High Resolution 1D/2D Urban Assessment
Landuse / Data





High Resolution 1D/2D Urban Assessment
Direct Rainfall Approach

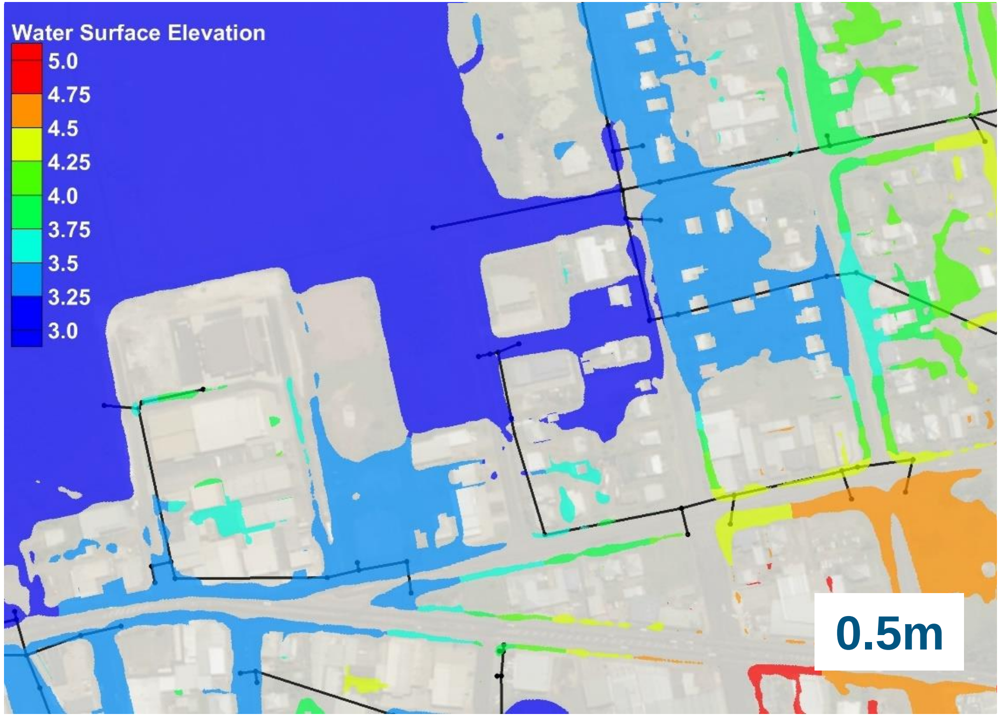
Inundation is mapped when depth exceeds 0.1m

High Resolution 1D/2D Urban Assessment
What Matters?

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



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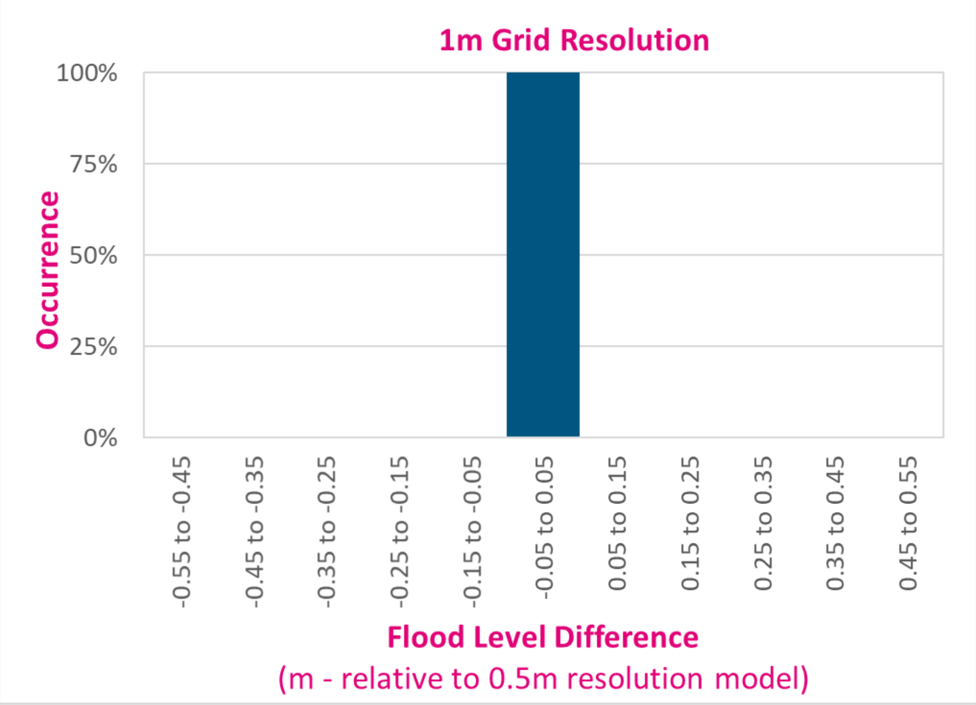

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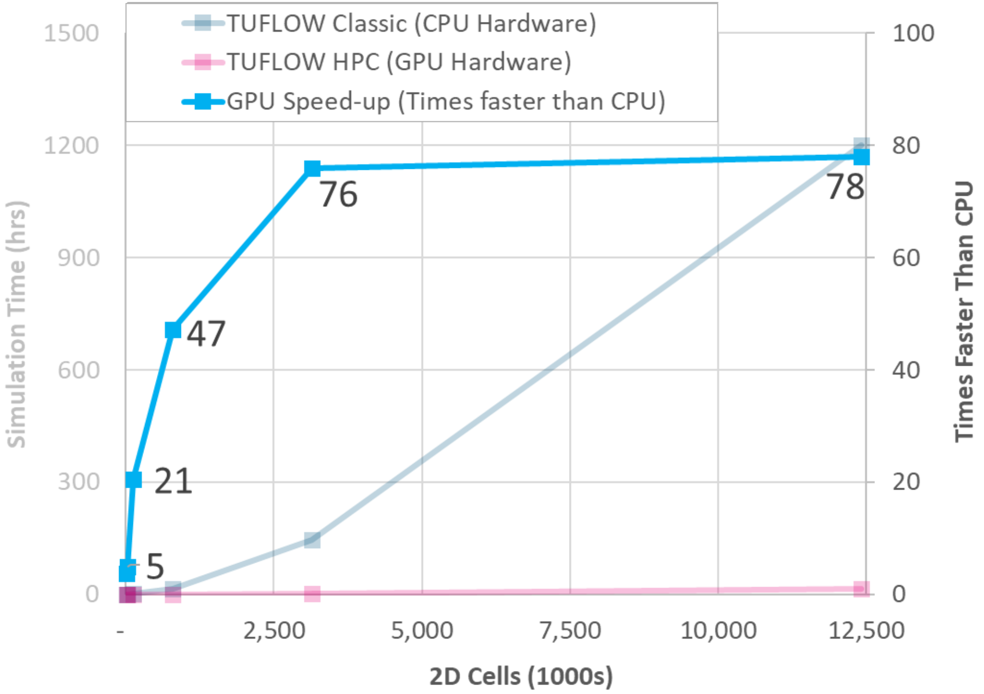
High Resolution 1D/2D Urban Assessment
What Matters?

Solver/Hardware Comparison
Simulation speed

	CPU	GPU
~~• 20m~~	~~0:12 hr~~	~~0:03 hr~~
~~• 10m~~	~~0:15 hr~~	~~0:03 hr~~
~~• 5m~~	~~1:32 hr~~	~~0:05 hr~~
• 2m	15:19 hr	0:20 hr
• 1m	14[illegible]0 hr	1:55 hr
• 0.5m	≈48 days	18.30 hr



CPU = 17-5960X CPU @3.00GHz GPU = 2 x GeForce GTX 980

Bundaberg Non-Urban Overland Mapping Study

Catchment Scale Modelling

BUNDABERG
REGIONAL COUNCIL

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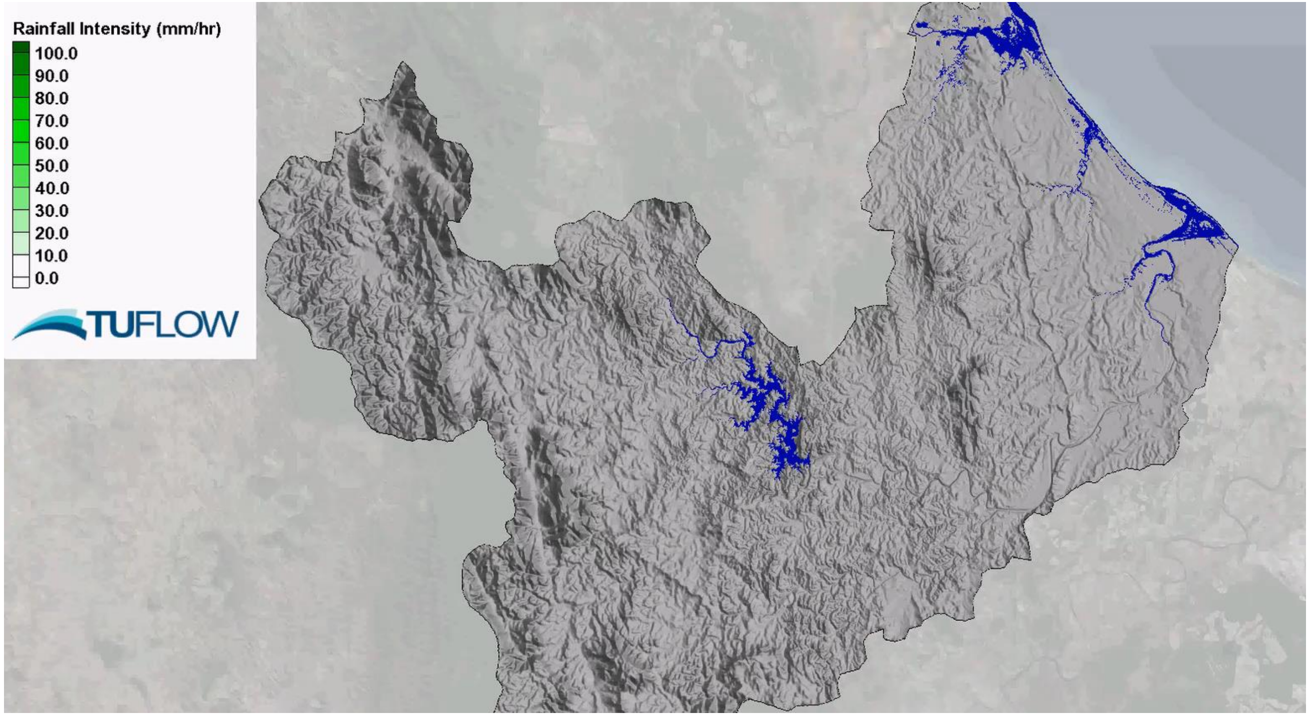
Bundaberg Non-Urban Overland Mapping Study
Catchment Scale Modelling

- 7,000 km^2 area
- 15m cell size
- 6 durations
- 1% AEP existing + future climate

Duration	Percentage of area where critical
10min	1.4%
20min	29.17%
30min	2.15%
1hr	24.96%
2hr	11.48%
6hr	2.2%
12hr	6.92%
24hr	9.49%
48hr	3.47%
72hr	8.76%



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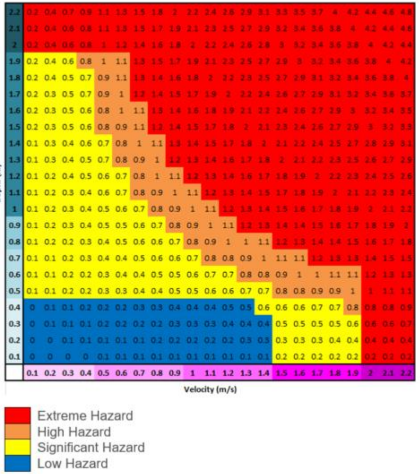
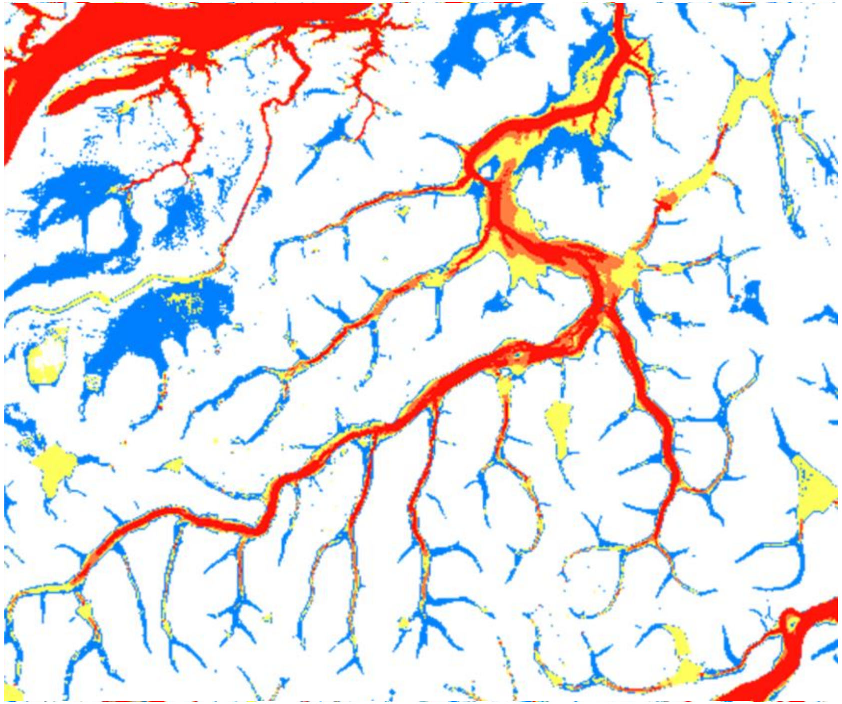
>30,000,000 2D cells



	Low	Significant	High	Extreme
Depth	<0.5	<2	<2	2+
Velocity	<1.5	<2	<2	2+
D x V Product	<0.6	0.6 to <0.8	0.8 to <1.2	1.2+



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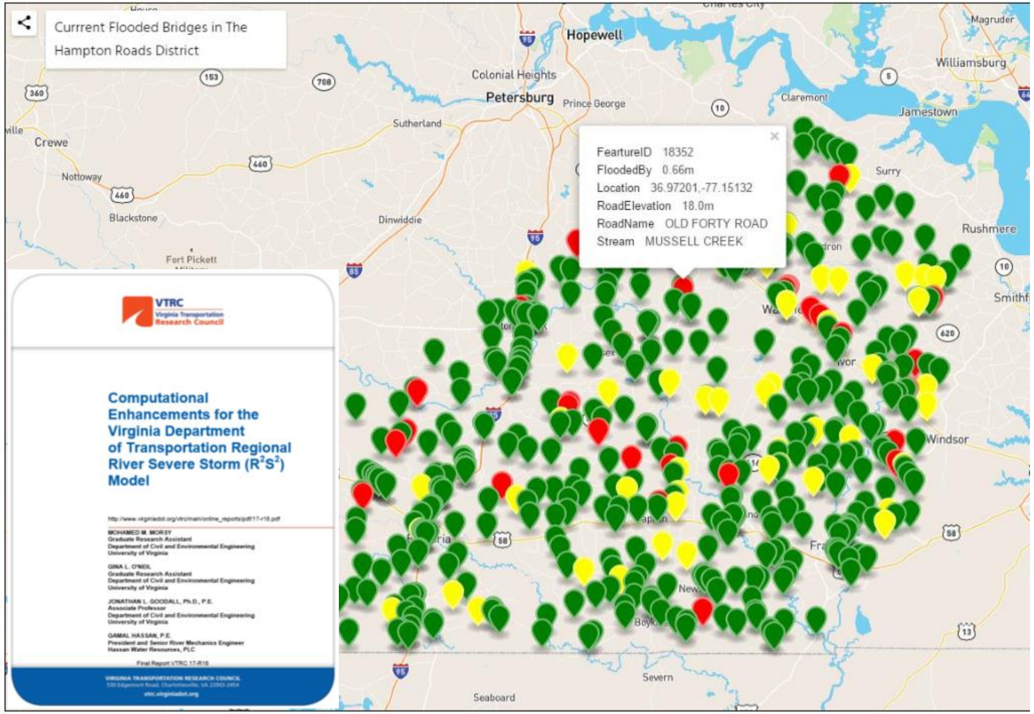
Real-time Flood Forecasting

Real-time Flood Forecasting

- Automated flood forecasting using Google Cloud GPU hardware
- NOAA rainfall forecast data
- Direct rainfall TUFLOW hydraulic simulation
- Real-time bridge inundation risk results are uploaded to a DoT website



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