The Future of 2D Hydraulic Modelling

2nd February 2021

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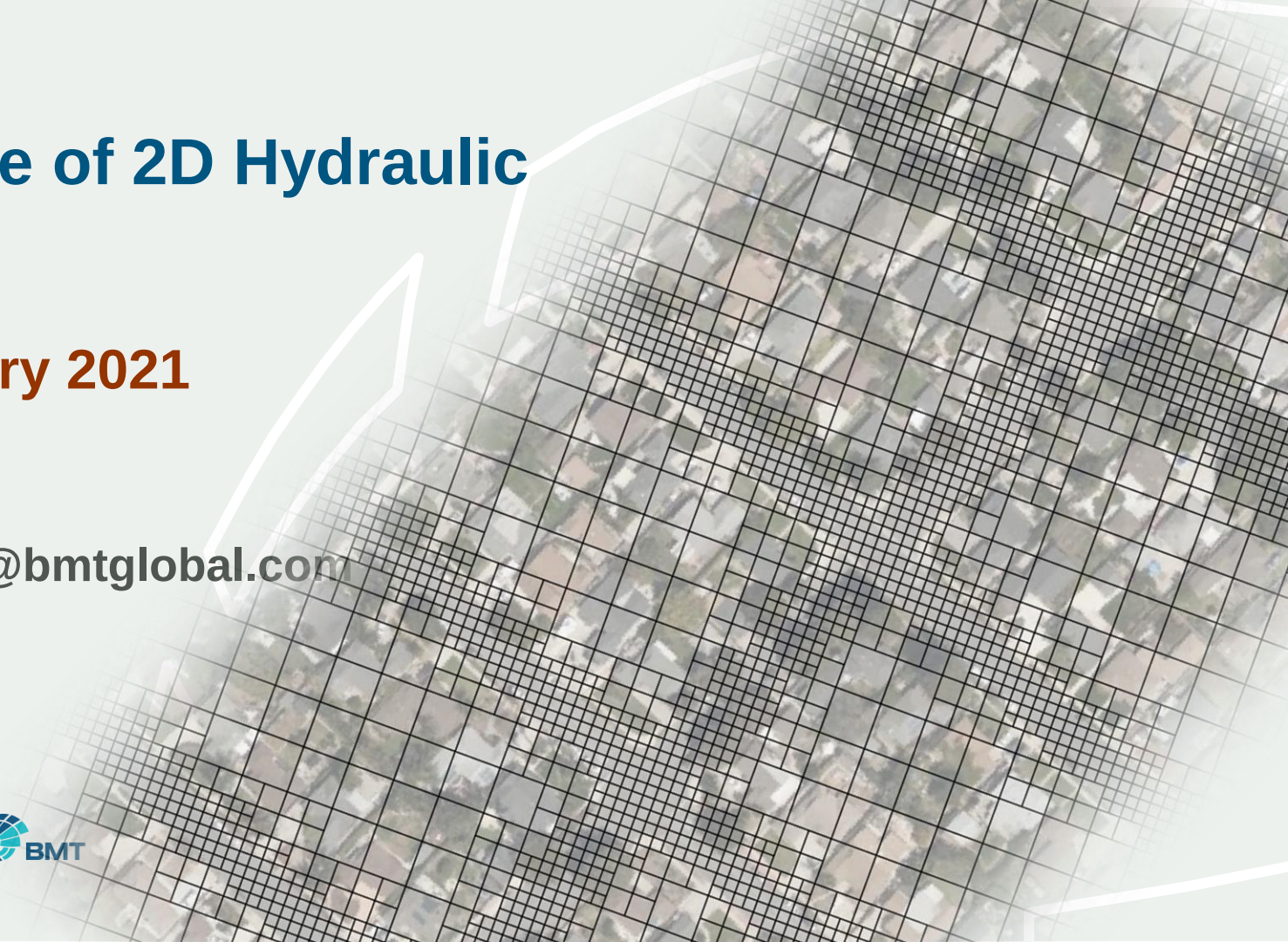
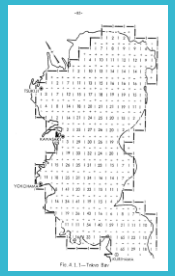
Duncan.kitts@bmtglobal.com

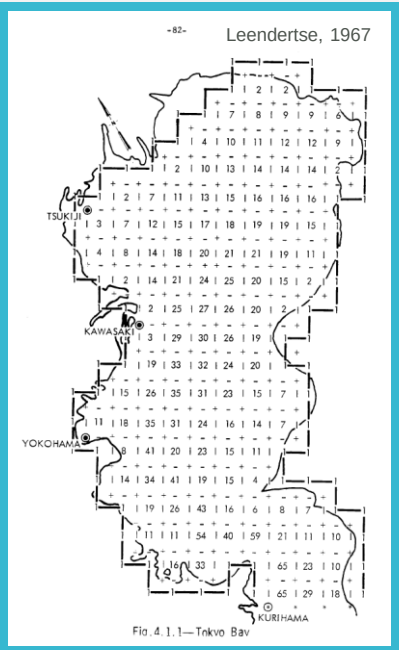


Evolution of 2D Hydraulic Modelling Timeline

1967

100 cells

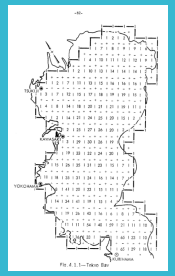




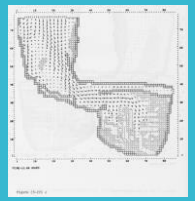
Coastal Bays

Evolution of 2D Hydraulic Modelling Timeline

1967
100 cells



1984
1,000



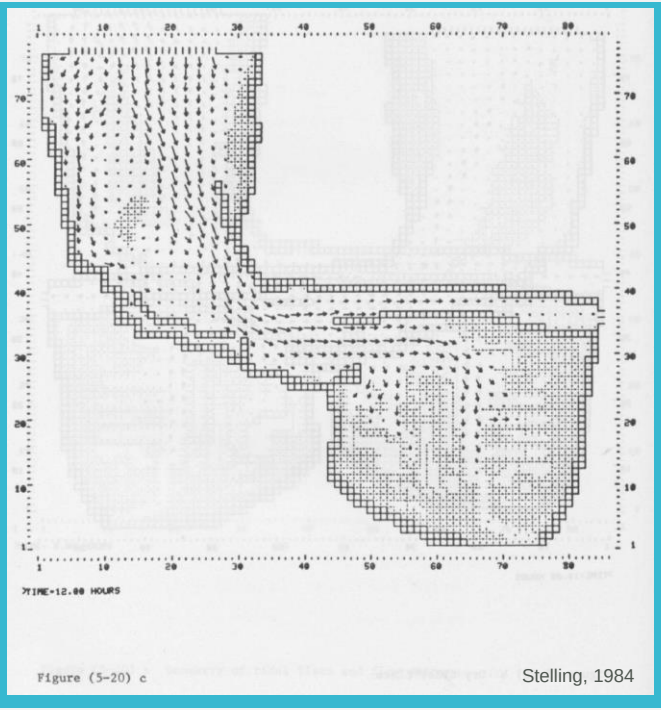


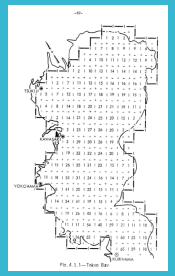
Figure (5-20) c

Stelling, 1984

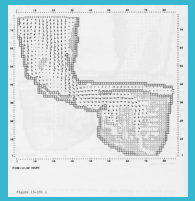
Coastal Bays

Evolution of 2D Hydraulic Modelling Timeline

1967
100 cells

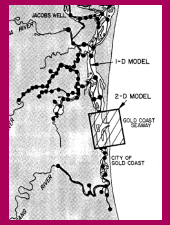


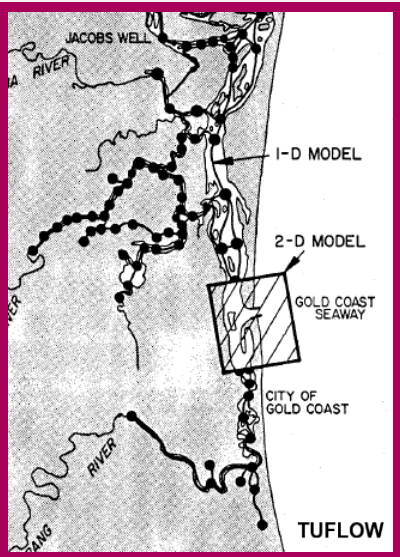
1984
1,000

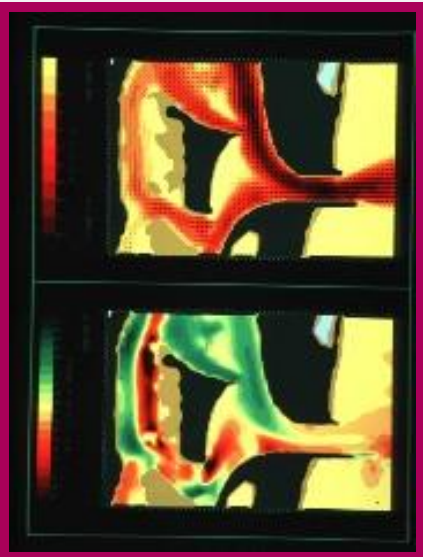


Coastal Bays

1990
10,000







Coastal Waters and Estuaries (Linked 1D/2D)

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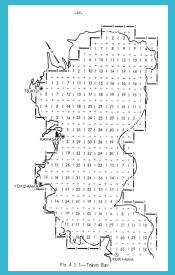
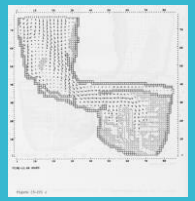
Evolution of 2D Hydraulic Modelling Timeline

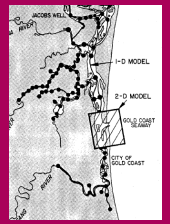
1967
100 cells

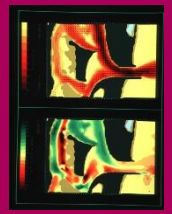


1984
1,000

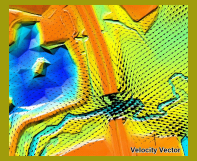


1990
10,000

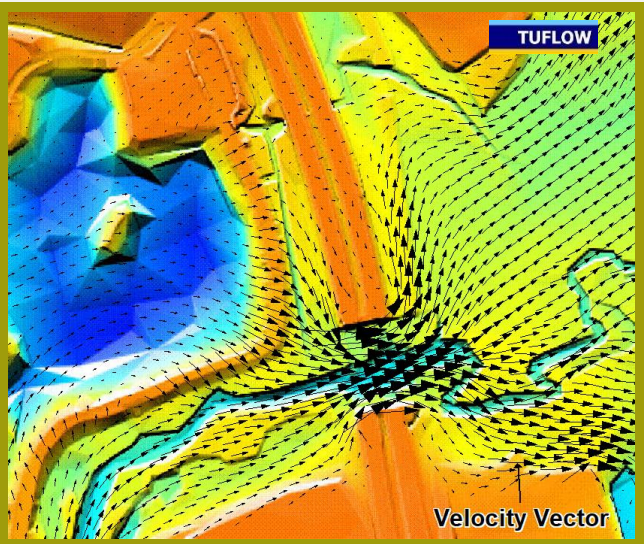




1998
50,000



Rivers (Flooding)



Coastal Waters and Estuaries (Linked 1D/2D)

Coastal Bays

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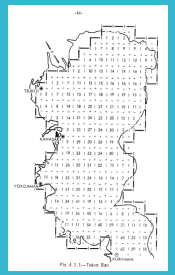
Evolution of 2D Hydraulic Modelling Timeline

1967
100 cells

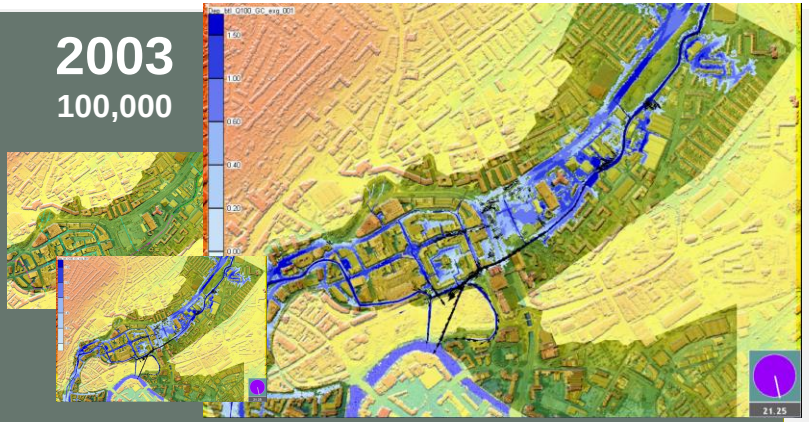


1984
1,000

1990
10,000

1998
50,000

2003
100,000



Pipes (1D) / Surfacewater (2D)

ries (Linked 1D/2D)

Coastal Bays

Evolution of 2D Hydraulic Modelling Timeline

1967 100 cells

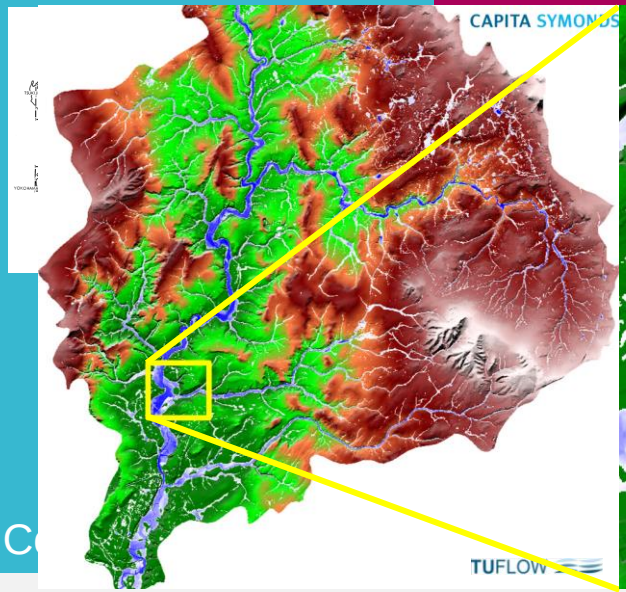
1984 1,000

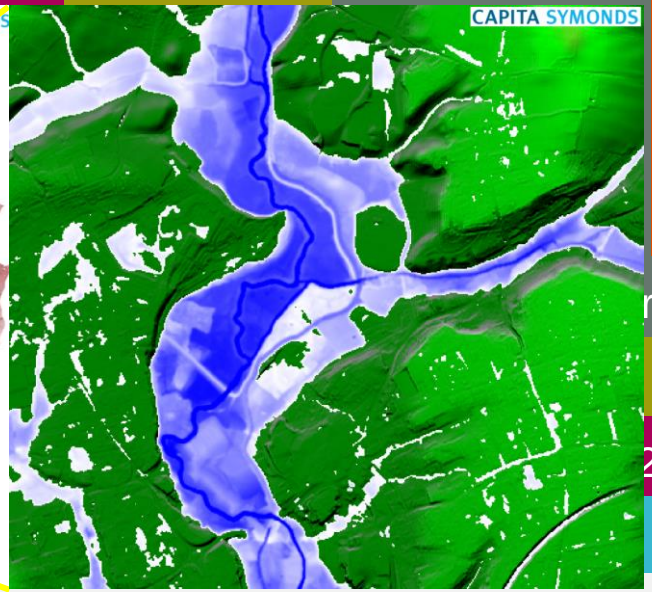
1990 10,000

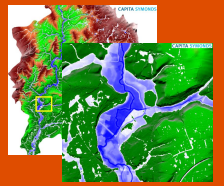
1998 50,000

2003 100,000

2013 10,000,000 (GPU)







Catchments

rfacewater (2D)

2D)

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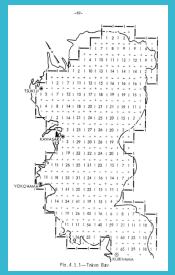
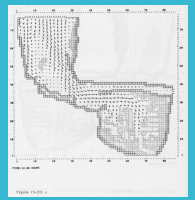
Evolution of 2D Hydraulic Modelling Timeline

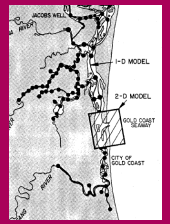
1967
100 cells

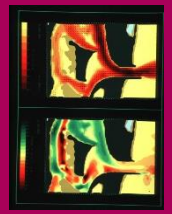


1984
1,000

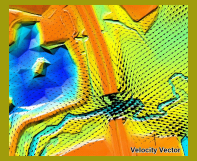


1990
10,000

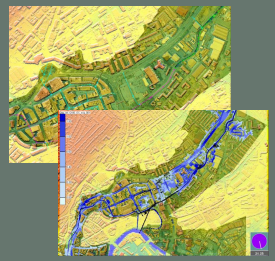




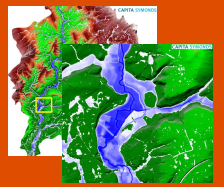
1998
50,000



2003
100,000



2013
10,000,000 (GPU)



2020s
>100,000,000

?

Catchments

Pipes (1D) / Surfacewater (2D)

Rivers (Flooding)

Coastal Waters and Estuaries (Linked 1D/2D)

Coastal Bays

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Quadtree
Automated Mesh Refinement

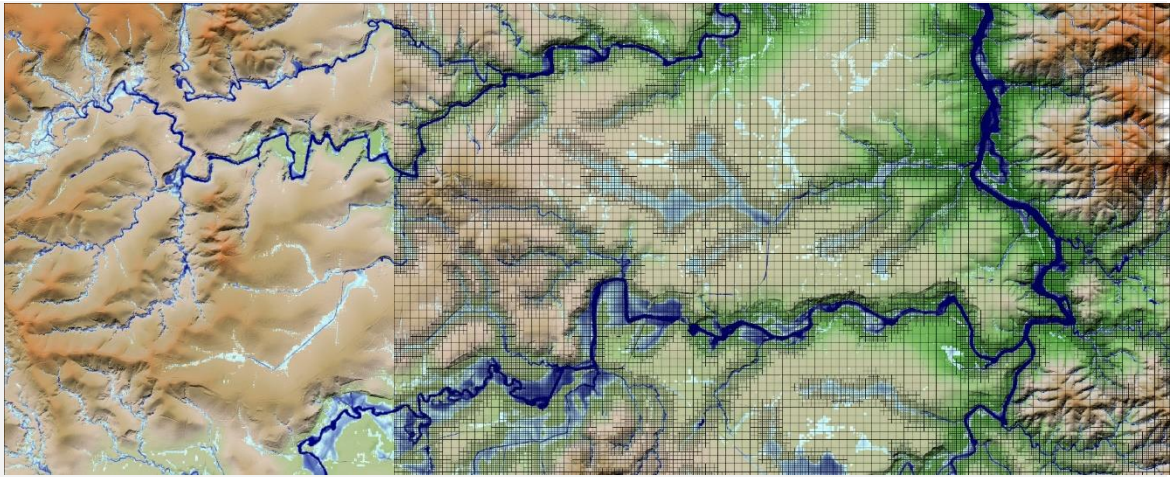
Vary Grid Cell Size within Fixed Grid Model

Very fast to setup

- Takes minutes

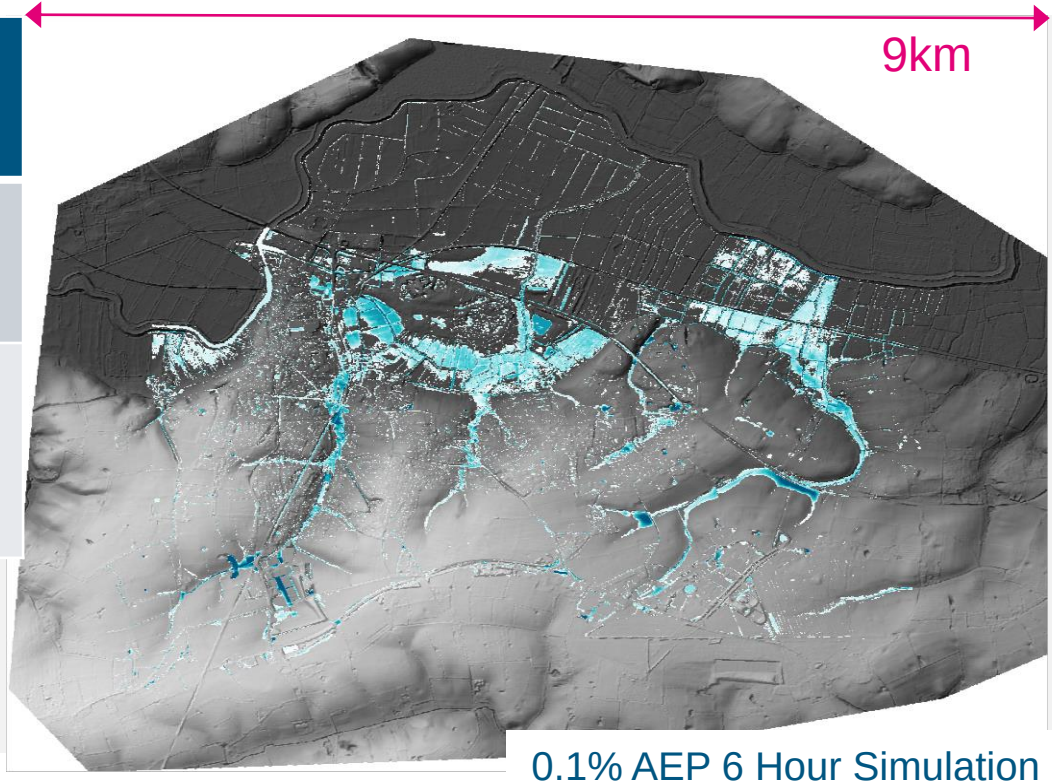
Use GIS layers to increase or decrease cell size

- e.g. flood zones, roads layer



Quadtree Performance
Whole Catchment Modelling

Model Scenario	2D Cell Count	Simulation Time (hh:mm)
Single Domain (2m resolution)	4,783,044	
3 Level Quadtree (2m / 4m / 8m)	695,909	



0.1% AEP 6 Hour Simulation
Direct Rainfall

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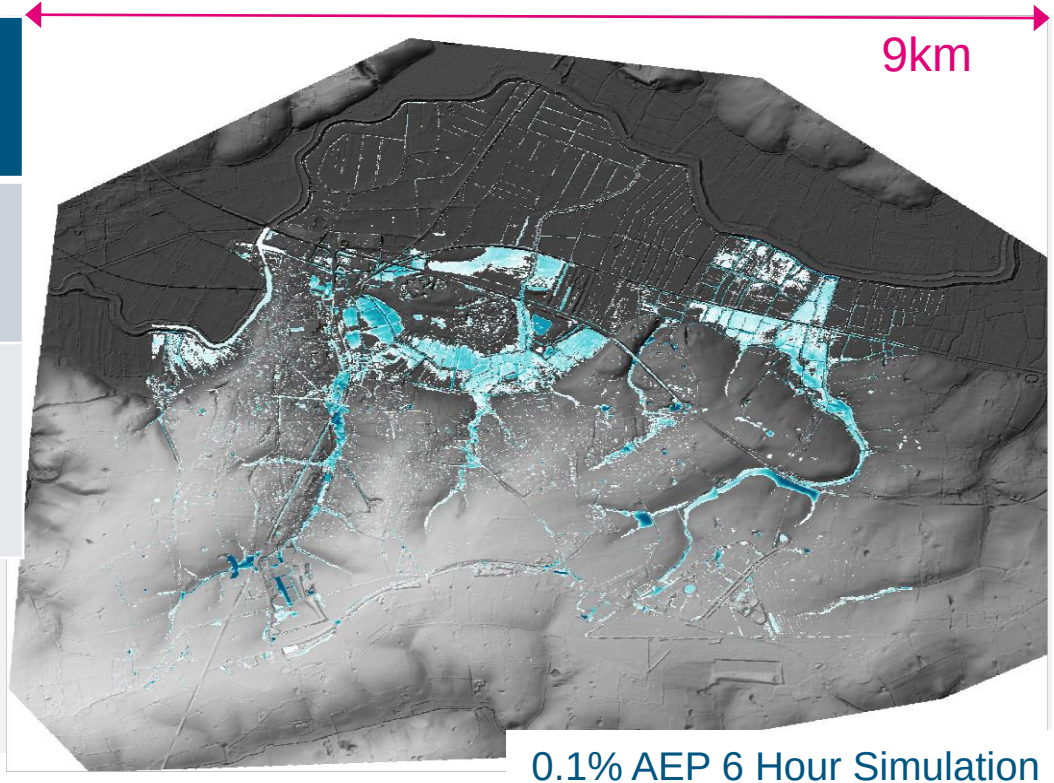
Quadtree Performance
Whole Catchment Modelling

Model Scenario	2D Cell Count	Simulation Time (hh:mm)
Single Domain (2m resolution)	4,783,044	2:40:44
3 Level Quadtree (2m / 4m / 8m)	695,909	35:37



0.1% AEP 6 Hour Simulation
Direct Rainfall

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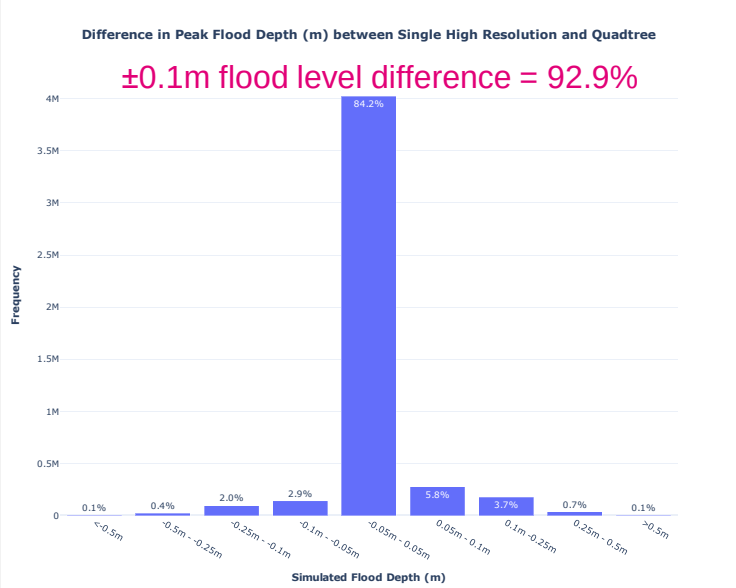
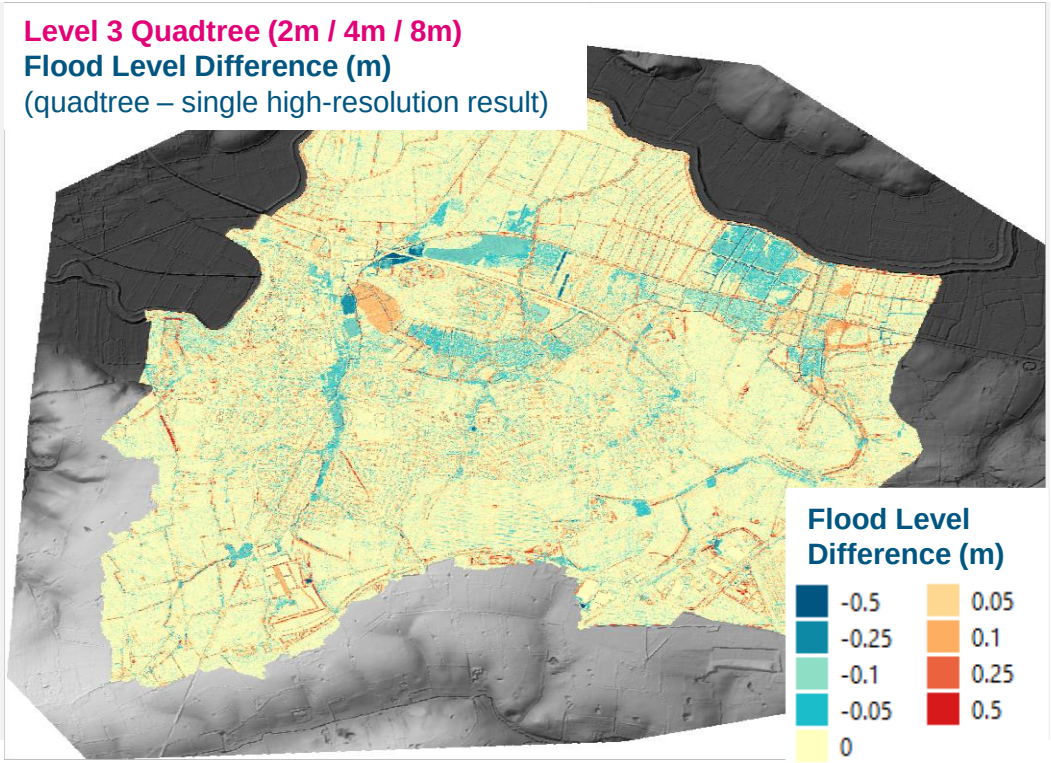
Quadtree Performance
Whole Catchment Modelling

Peak Flood Level Difference

Quadtree - Single High-Resolution Result



Level 3 Quadtree (2m / 4m / 8m)
Flood Level Difference (m)
(quadtree – single high-resolution result)



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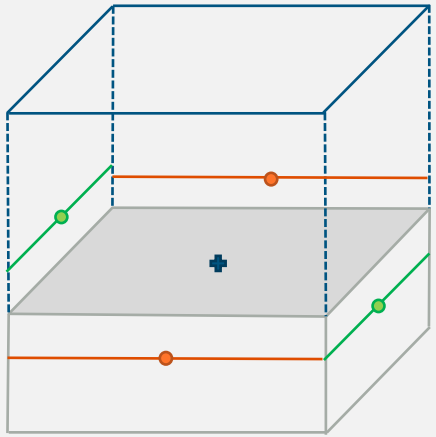
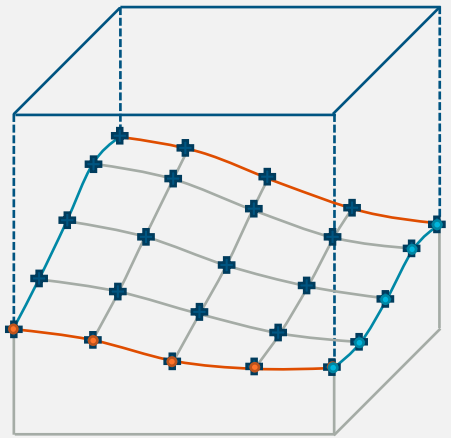
Sub-Grid Sampling (SGS)

Makes use of all terrain information within a 2D cell

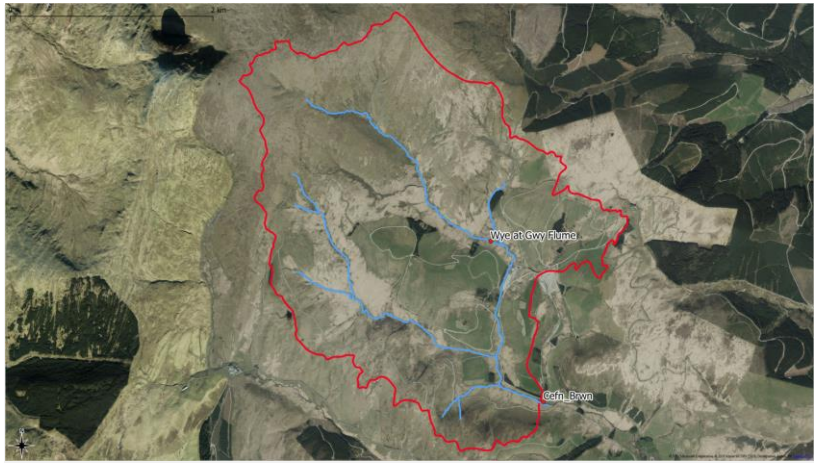
Without SGS
(Conventional Approach)

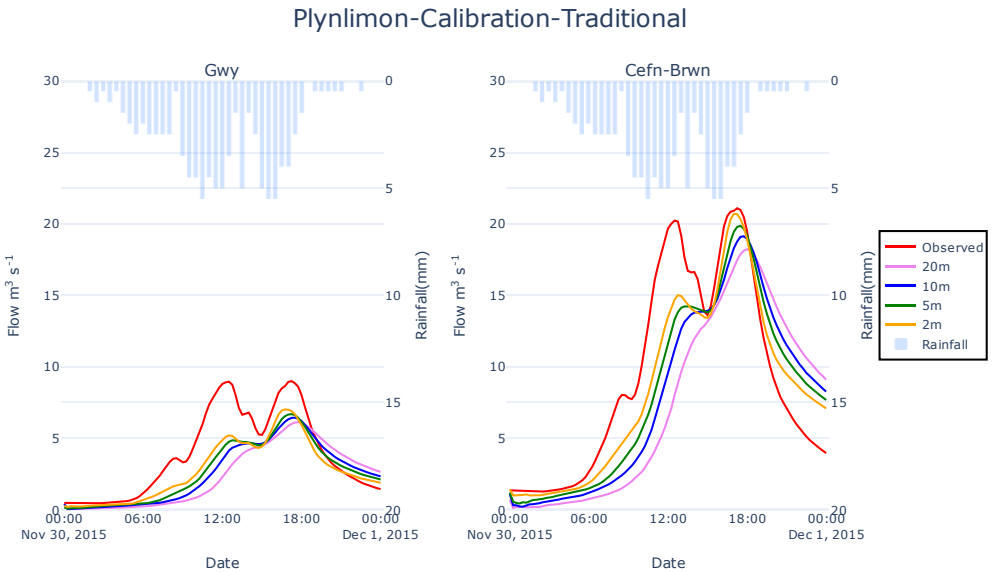


With SGS

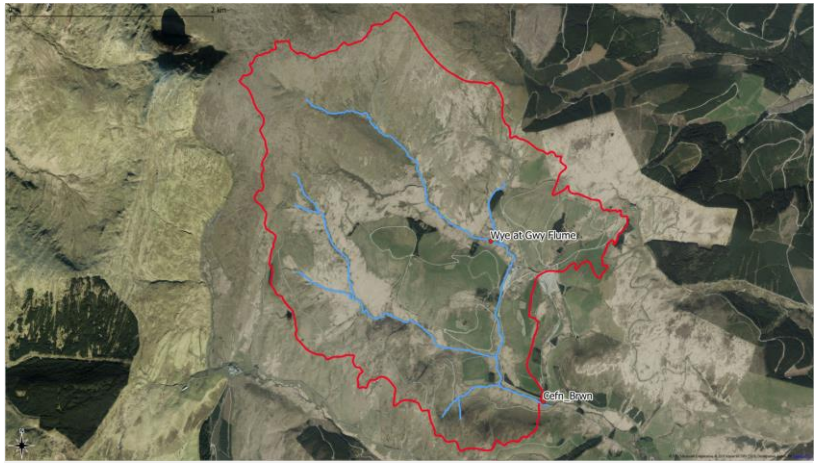


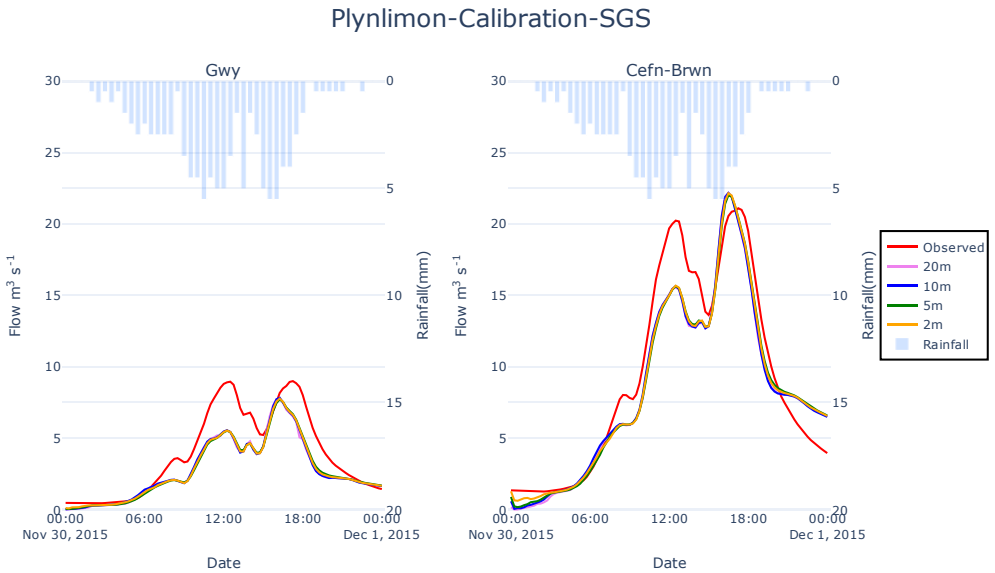
Whole Catchment Modelling Without SGS (Traditional)





Whole Catchment Modelling With SGS



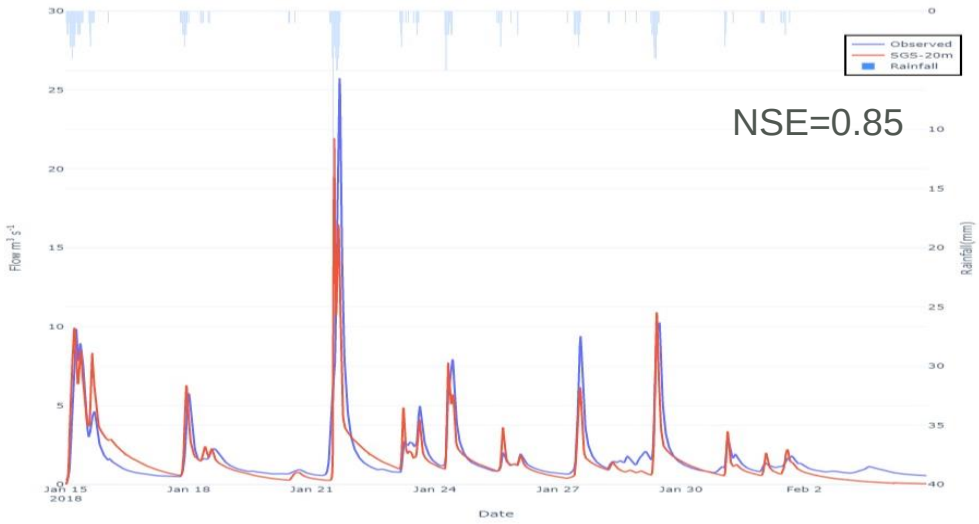


Applications
Whole Catchment

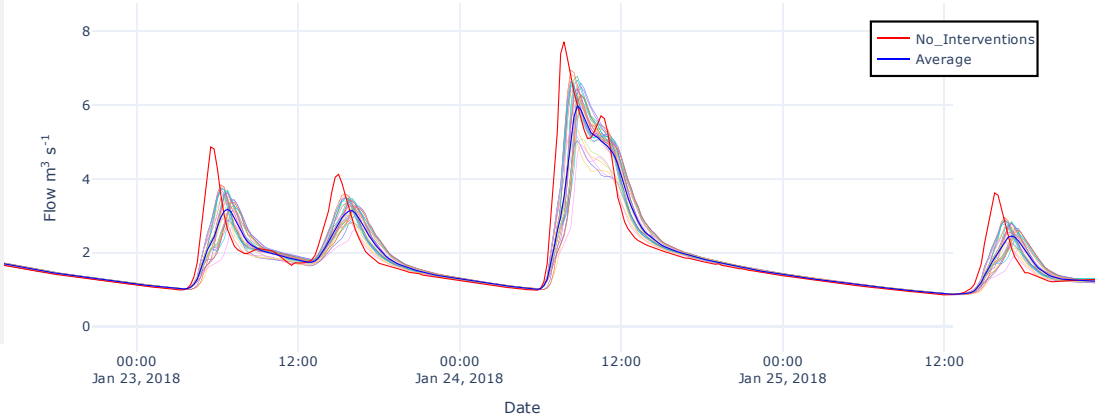
Larger mesh sizes provide similar results at fraction of computational time

- Longer term continuous modelling is possible
- More scenarios can be run

Can be used in conjunction with Quadtree



Plynlimon: Cefn-Brwn Gauge-NFM Measures



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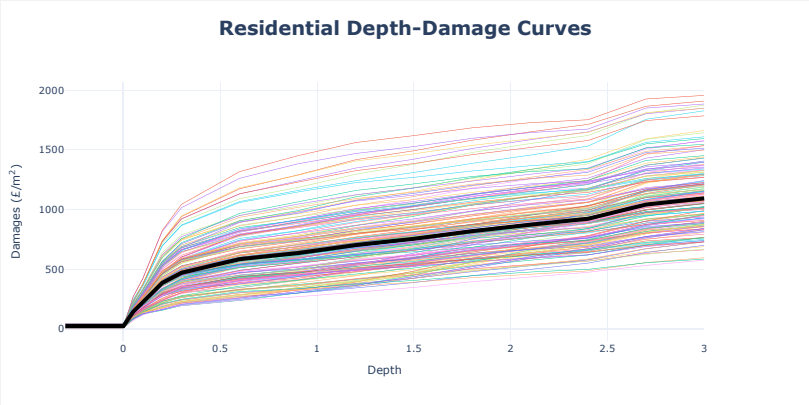
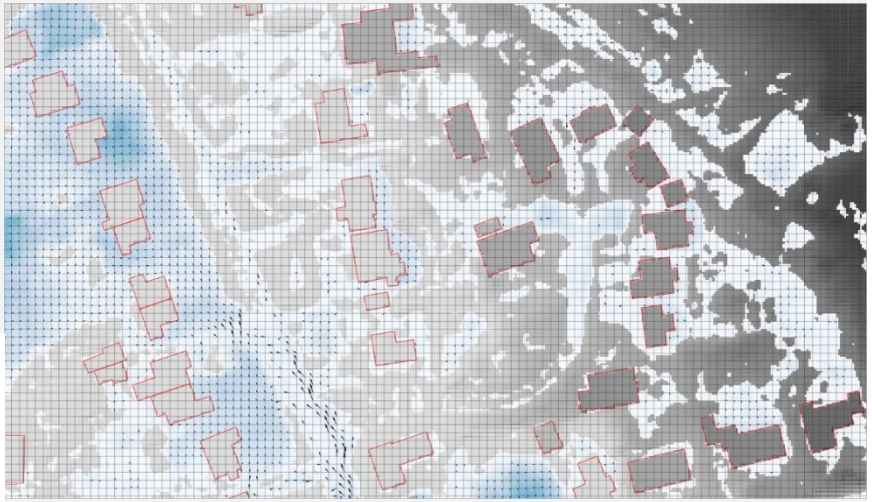
Applications
Property Damages In Urban Areas

Flood Risk Management Appraisal is based on Benefit Cost Ratio

Benefits based on Flood Damages

- Accurate representation of property flood depths is essential





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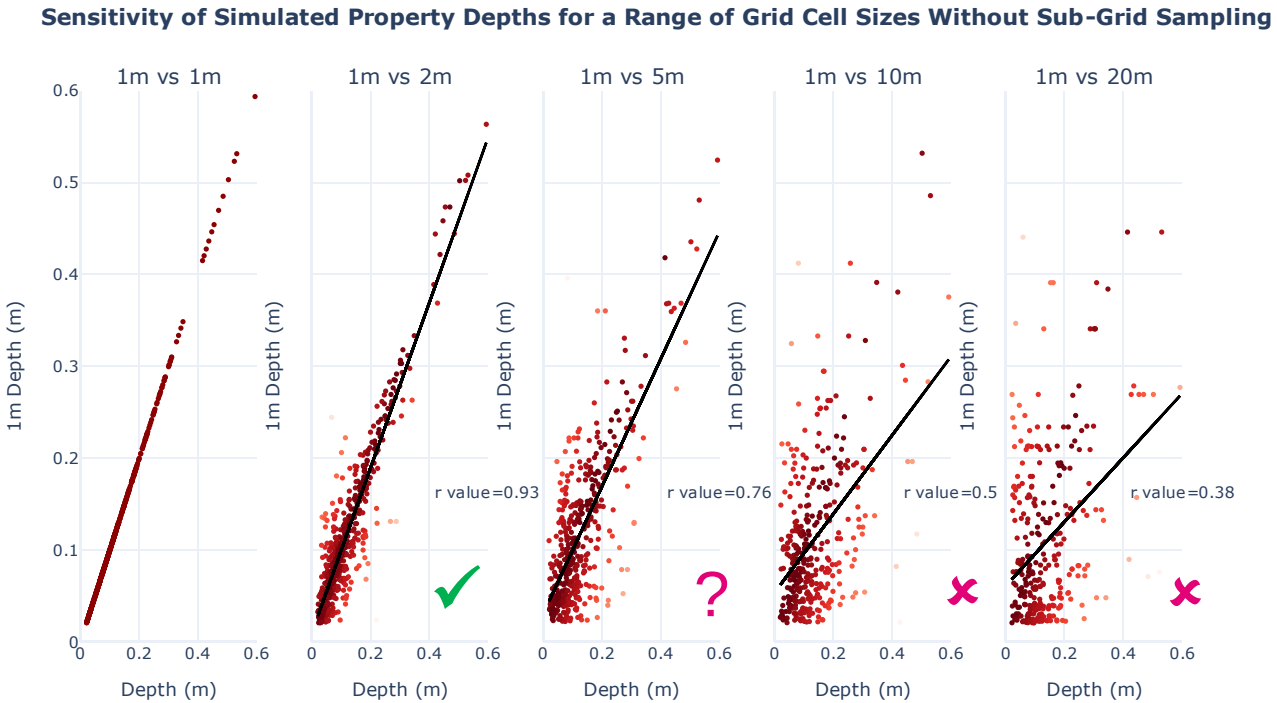
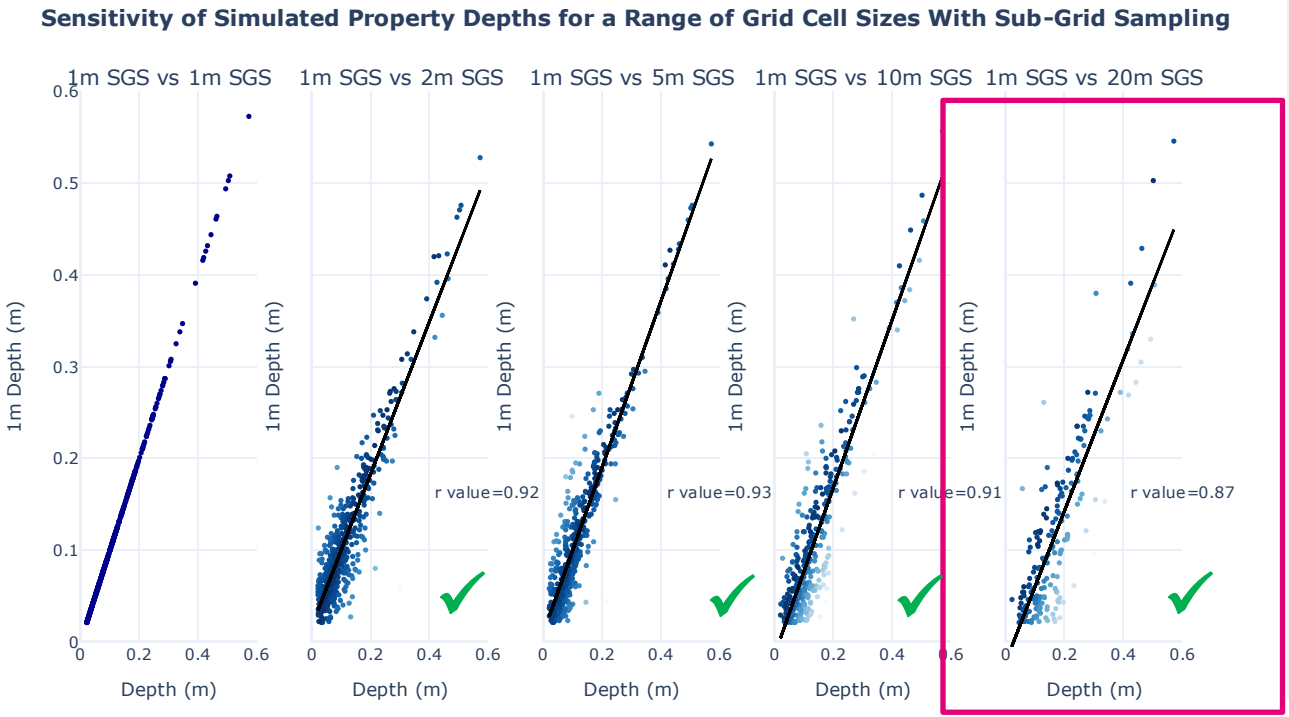
Property Flood Depths Without SGS (Traditional)

Results are Sensitive to Mesh Resolution



Property Flood Depths With SGS

With SGS, 20m output is a closer fit to 1m outputs than traditional



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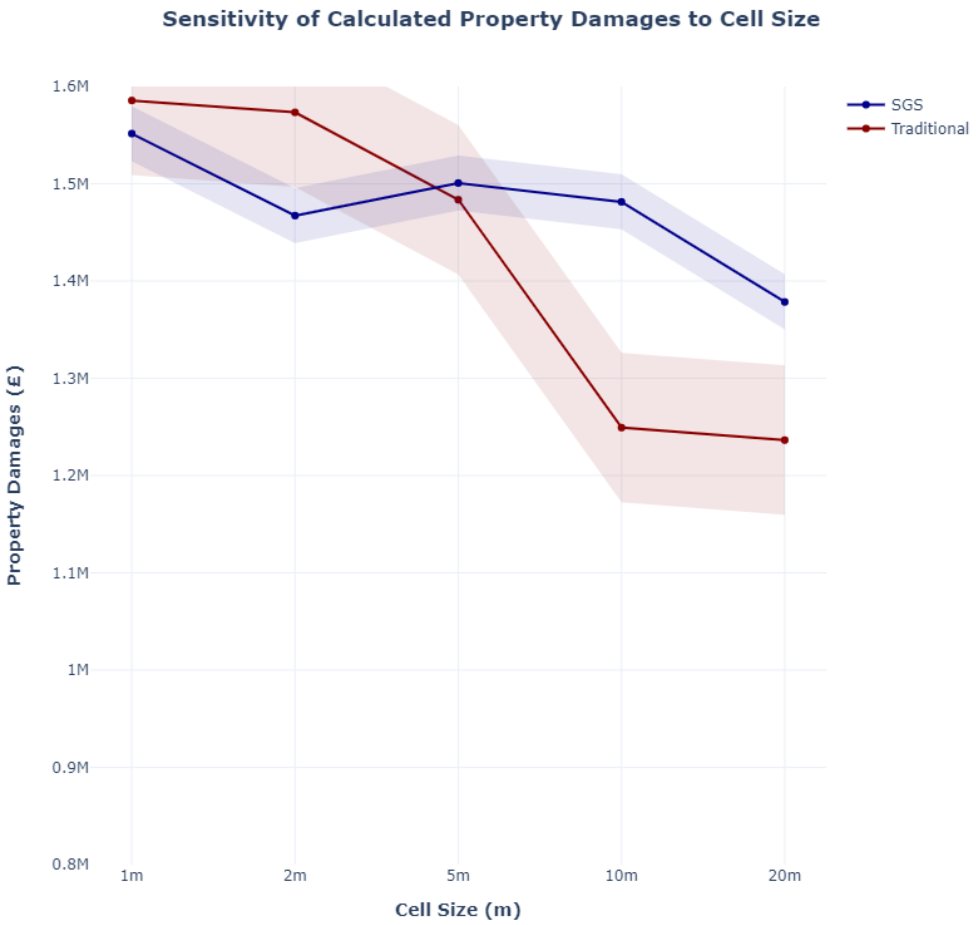
Property Flood Depths Run Times and Flood Dep

~90% correlation…

…but over 30 times quicker!!

Greater consistency in simulated flood depths and therefore damages



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Future of 2D Hydraulic Modelling
Conclusion

2D Hydraulic Modelling

- Major advancements over the last 50 years
- Wide range of schemes… beware of the simplistic schemes and even advanced 2D Schemes still have deficiencies

However…

- Can now vary cell sizes (very easily) for fixed grid models **(Quadtree)**
- Consistent results using much coarser cell sizes **(SGS)**

Above combination a game-changer

The future is looking bright for accurate 2D modelling