Simulating the effect of Tsunamis within the Build Environment

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Outline

- AnuGA Inundation Model
- Algorithm
- Model Validation
- Conclusion

Acknowledgements

- GA: Ole Nielsen, Duncan Gray, Adrian Hitchman, Chris Zoppou, Trevor Dhu
- ANU: Stephen Roberts, Darran Edmundson, Drew Whitehouse, Matthew Hardy, Linda Stals, Peter Row, Jack Kelly, John Jakeman

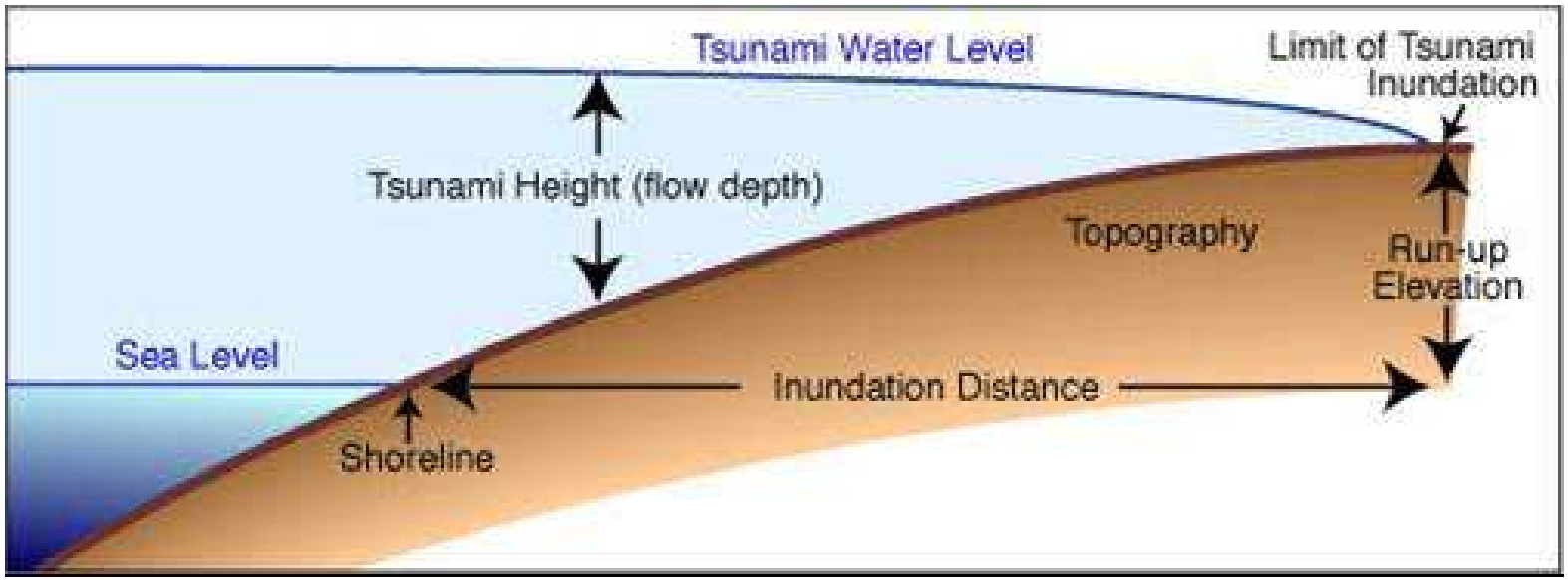
Purpose of the GA Inundation Modelling Project

Provide tools to support hazard and risk modelling for Australia and the region, thereby facilitating improved disaster mitigation and management.

Tsunami and related fire damage at Aonae, SE Okushiri Island, Japan. More than 120 people were killed in Japan (Okushiri and Hokkaido Islands) by the 1993 tsunami.

Purpose of the GA Inundation Modelling Project

- Develop numerical modelling capabilities to simulate inundation events such as those from tsunami run-up and storm surge.
- Collaborative development of AnuGA inundation model since January 2004.



AnuGA Inundation Model

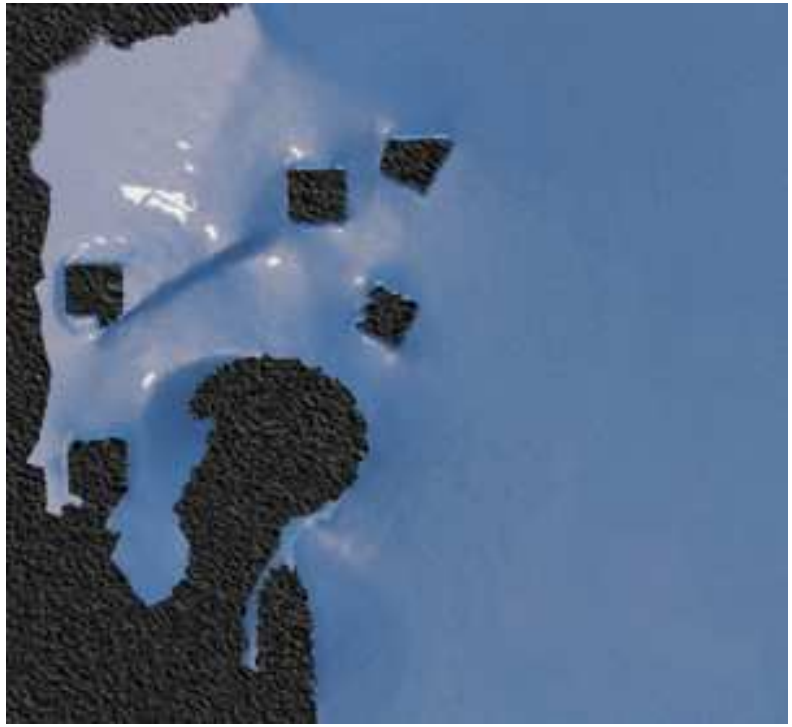
- Object Oriented implementation of a finite-volumes method for solving the Shallow Water Wave Equation based on state of the art methods derived from compressible gas dynamics
- Able to handle realistically sized situations (but not yet real time)
- Suitable for a wide range of flow problems
- Based exclusively on Open Source Software Components and planned to be released as such

Movie Steel Works

With Buildings

AnuGA Inundation Model

- Water flow described by Shallow Water Wave Equation
- Discretised using finite-volumes method (triangular mesh)
- Fluxes computed using the Central Scheme
- Time stepping based on weighted combinations of First order Euler.
- Time step determined by triangle size and wave speed (CFL)
- Second order with respect to spatial dimensions

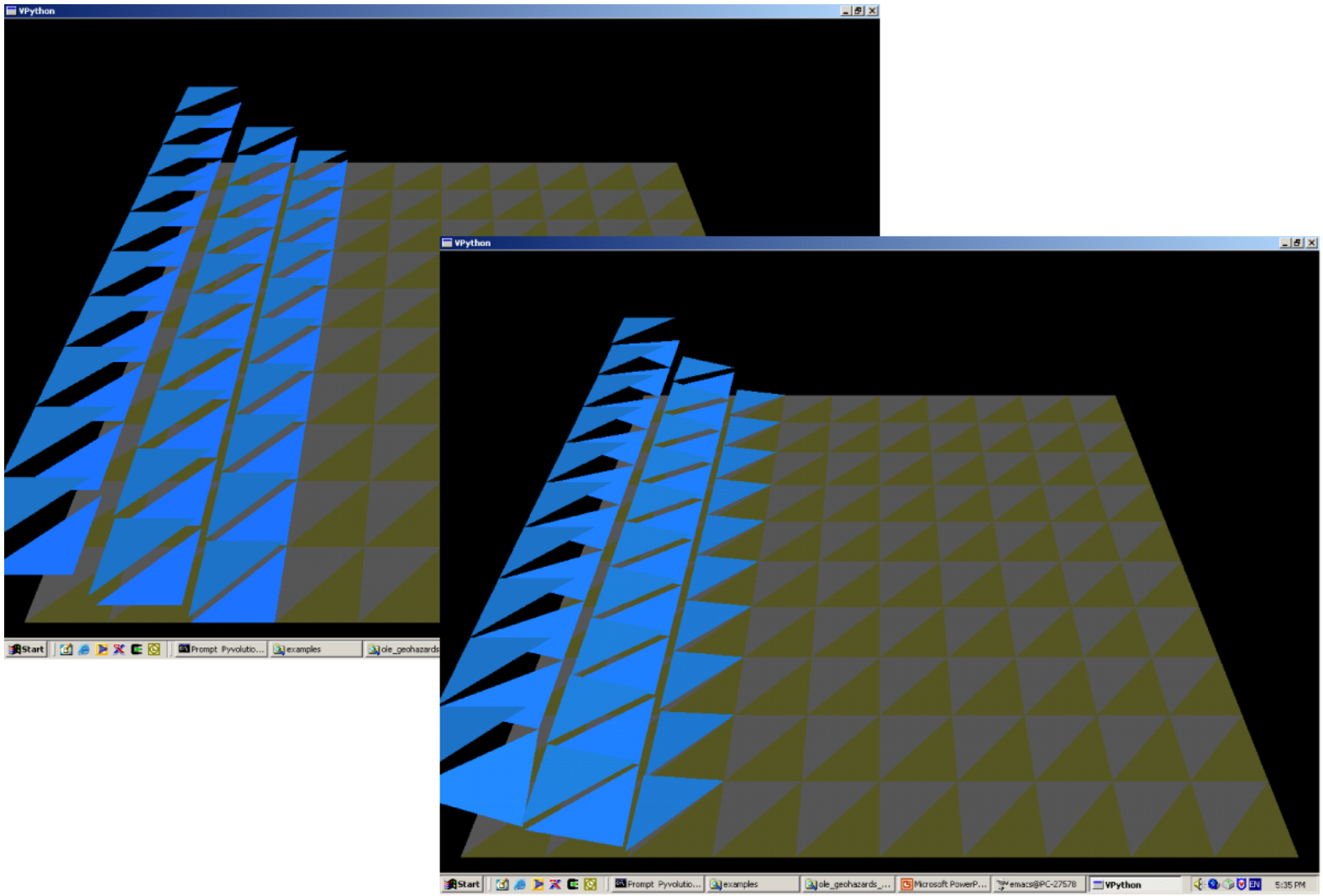


Quantities and Equations

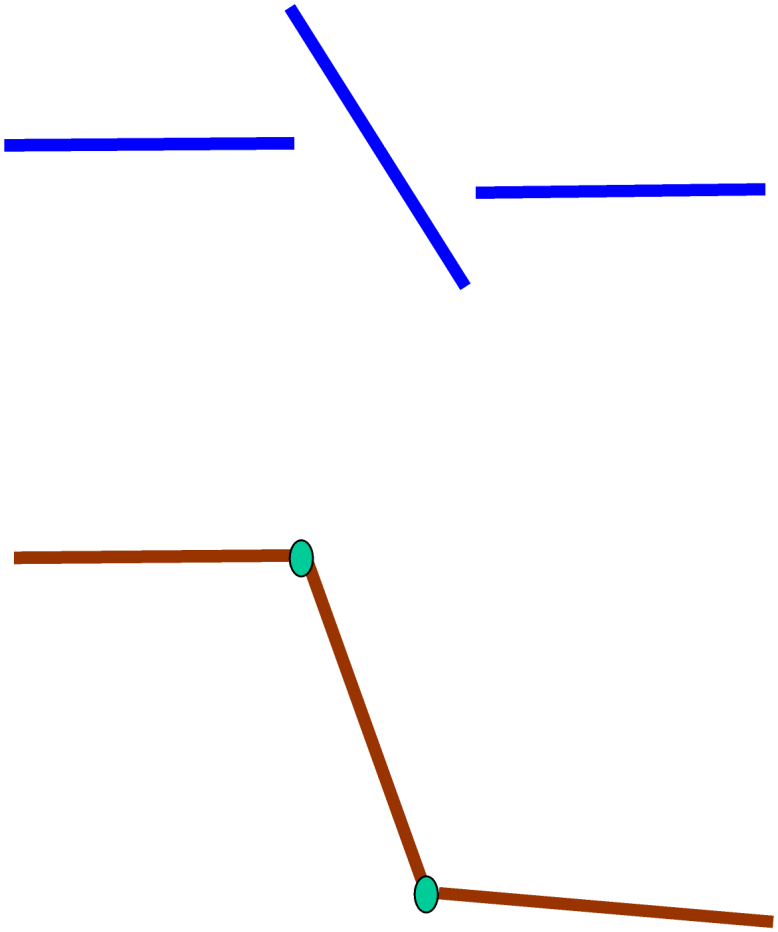
- Conserved quantities:
  - Water stage ($w = z + h$)
  - (or) Water Depth (h)
  - Horizontal momentum (uh, vh)
- Other quantities:
  - Bed elevation (z)
  - Friction (η)
  - Other
- One dimensional Shallow Water Wave Equation

$$\begin{bmatrix} h \\ uh \end{bmatrix}_t + \begin{bmatrix} uh \\ u^2h + \frac{1}{2}gh^2 \end{bmatrix}_x = \begin{bmatrix} 0 \\ -ghz_x \end{bmatrix}$$

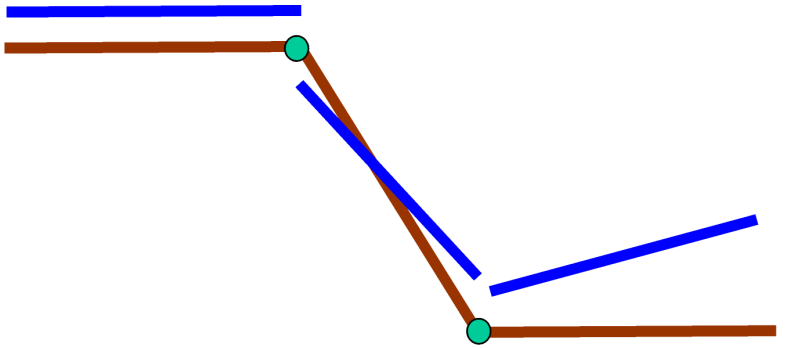
First and Second Order Reconstruction



Limiting on Depth or Stage?



Pure depth limiter may cause wobbles in deep water



Pure stage limiter may cause negative depths

AnuGA Capabilities

- CAN seamlessly model the process of wetting and drying as water advances upon and recedes from the area of inundation.
- Suitable for simulating:
  - water flow onto a beach or dry land
  - flow around structures such as buildings
  - hydraulic shocks (sudden jumps in water level)
- CAN'T model vertical velocities or breaking waves.

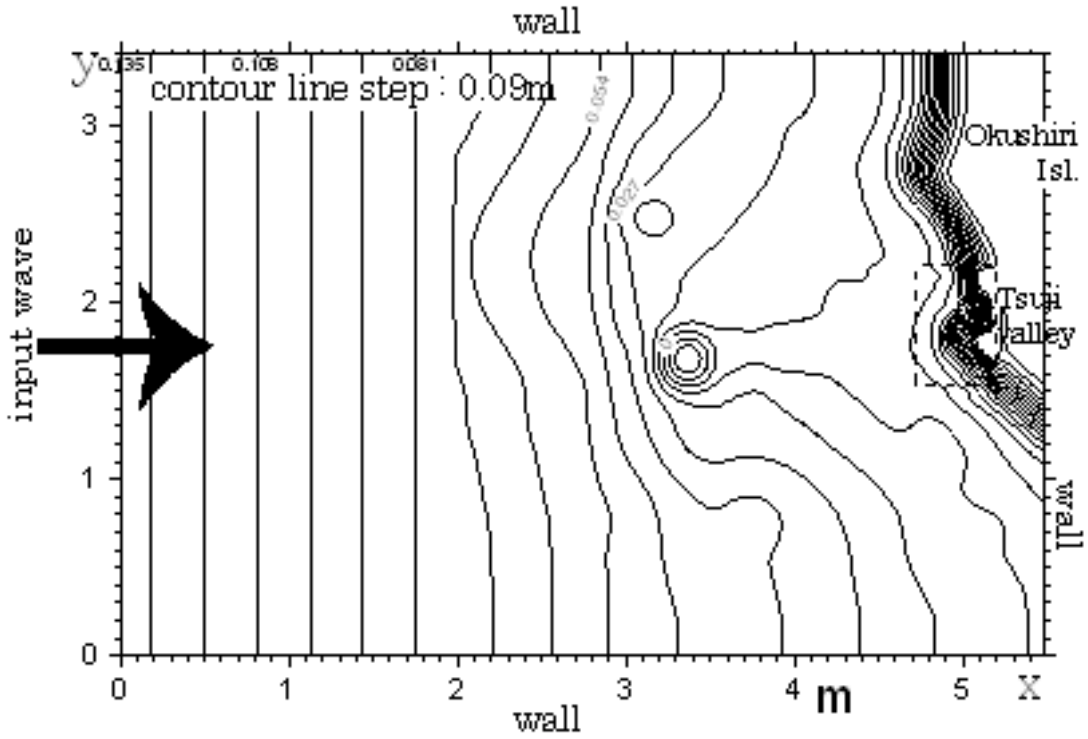
AnuGA Software Development

- Written in Python
- Object Oriented
- Bottlenecks written in C
- Overall framework is general
- Open source components
- Automated unit testing
- Subversion for revision control
- Issue tracking (TRAC)
- Elements of agile project management

Model Validation

- Validate Numerical scheme against known analytical solutions (watch this space!)
- Validate AnuGA model against measured laboratory wave tank data (done)
- Identify and, where possible, acquire appropriate real-world datasets for modelling of historical events (future plans)

Validation Scenario



Benchmark Scenario #2 selected from 3rd Int'l Workshop on LWRU 2004: Tsunami Run-up onto a Complex Three-dimensional Beach.

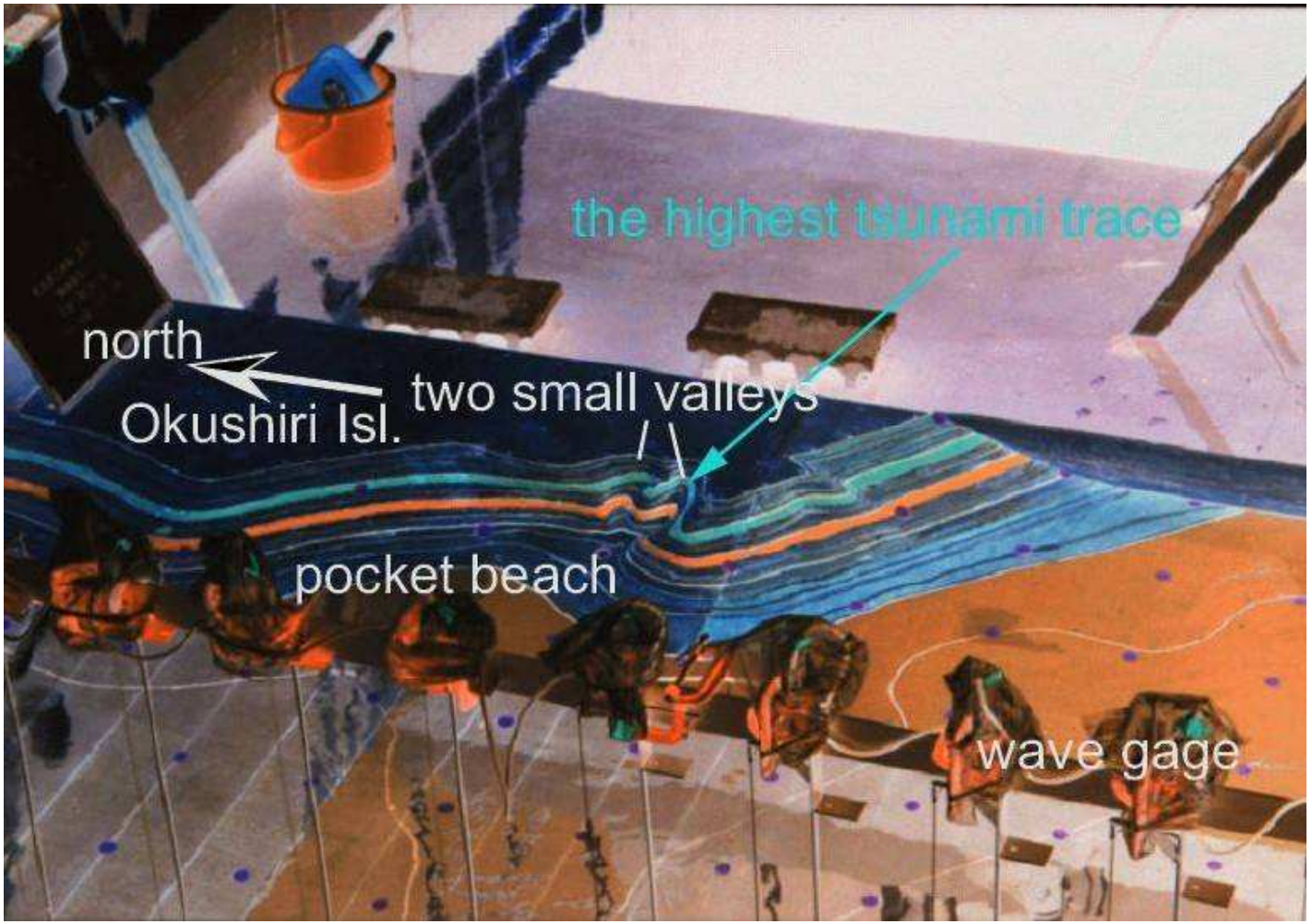
1/400 scale laboratory experiment of the Monai run-up (Okushiri Island, Japan, 1993).

Validation Scenario

Experiment conducted in large-scale tank (205 m long, 6 m deep, 3.4 m wide) at Central Research Institute for Electric Power Industry in Abiko, Japan.

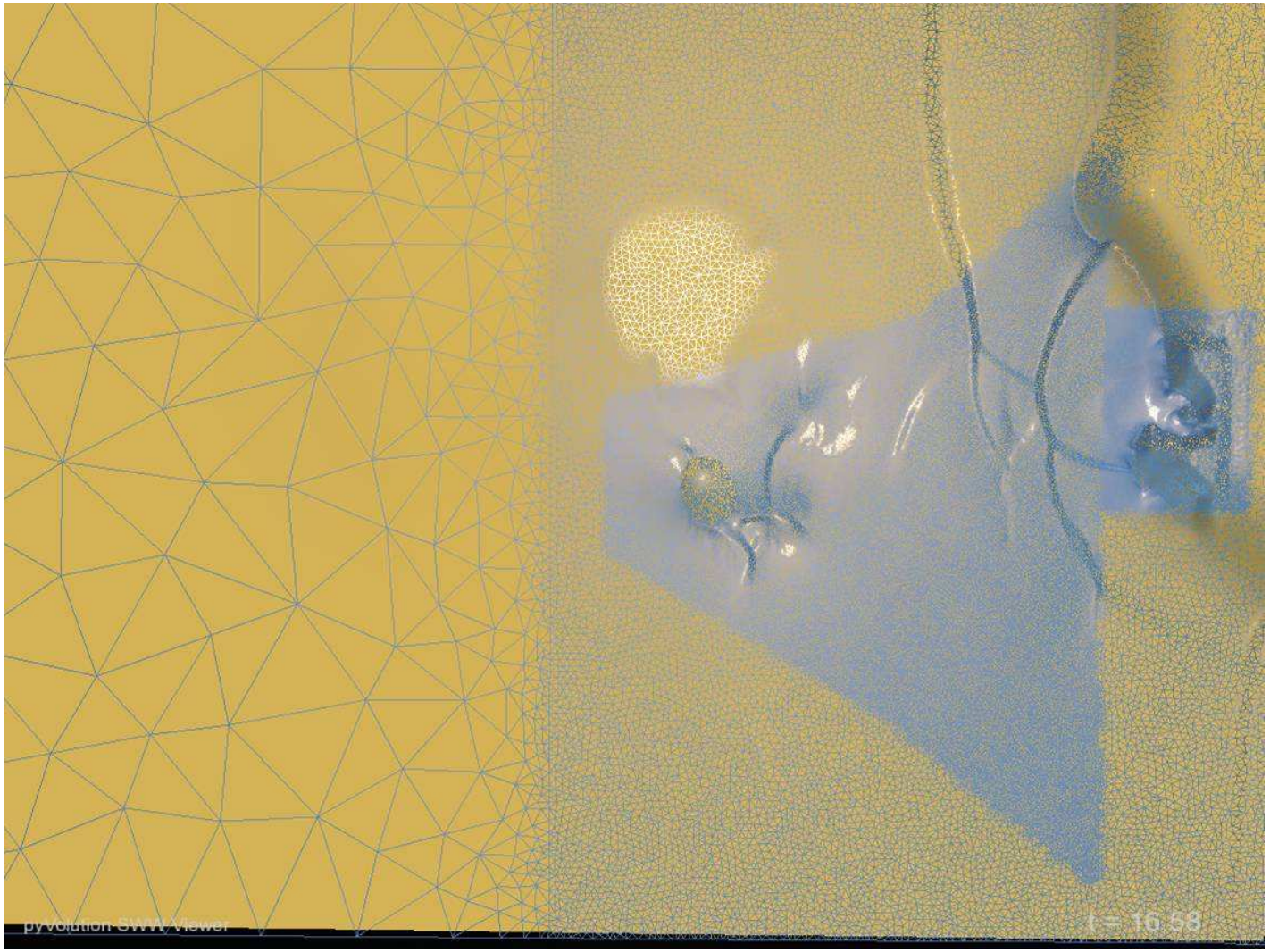
Large Wave Flume CRIEPI, Japan

Validation Scenario



Movie

Validation Scenario



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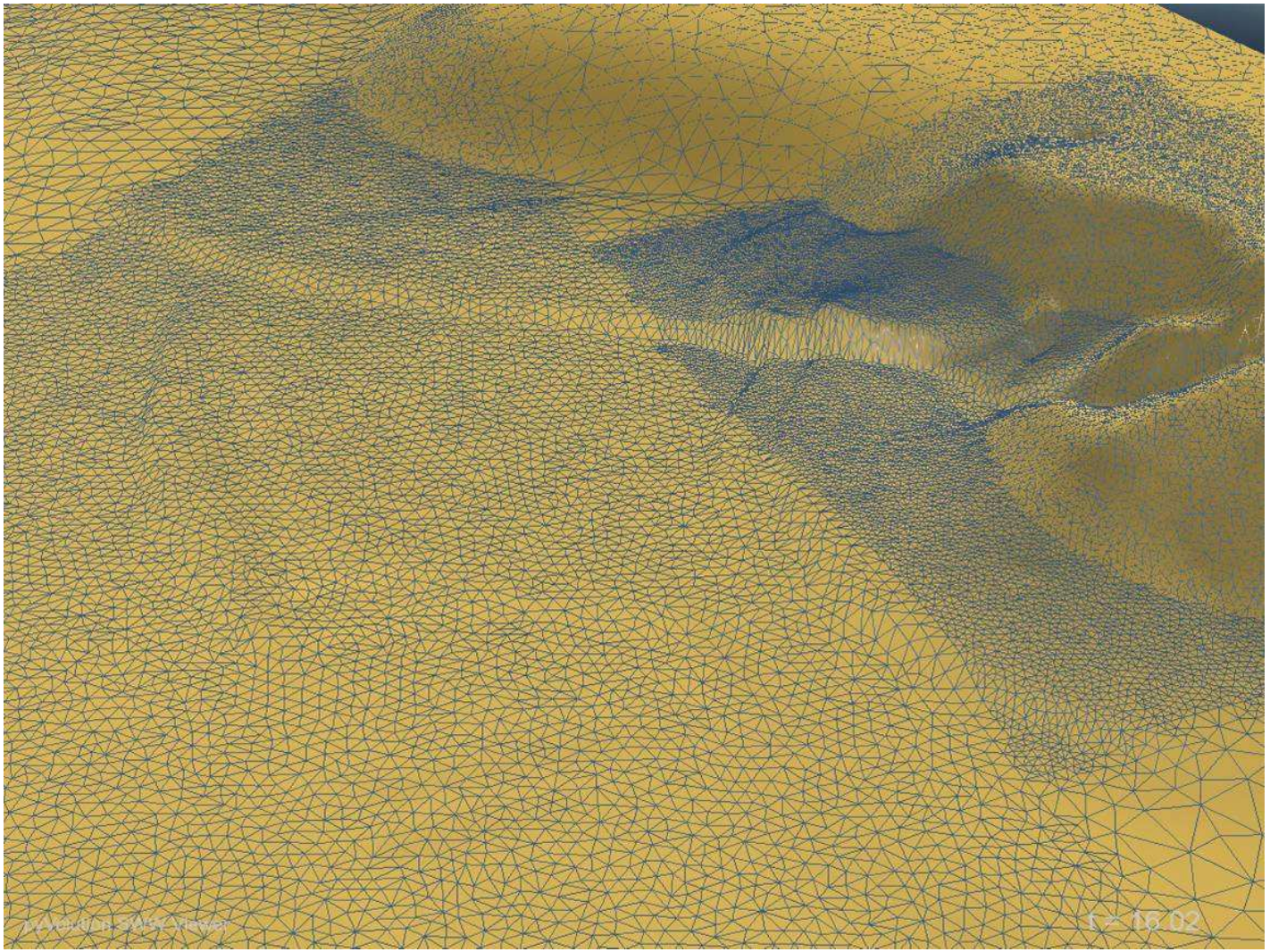

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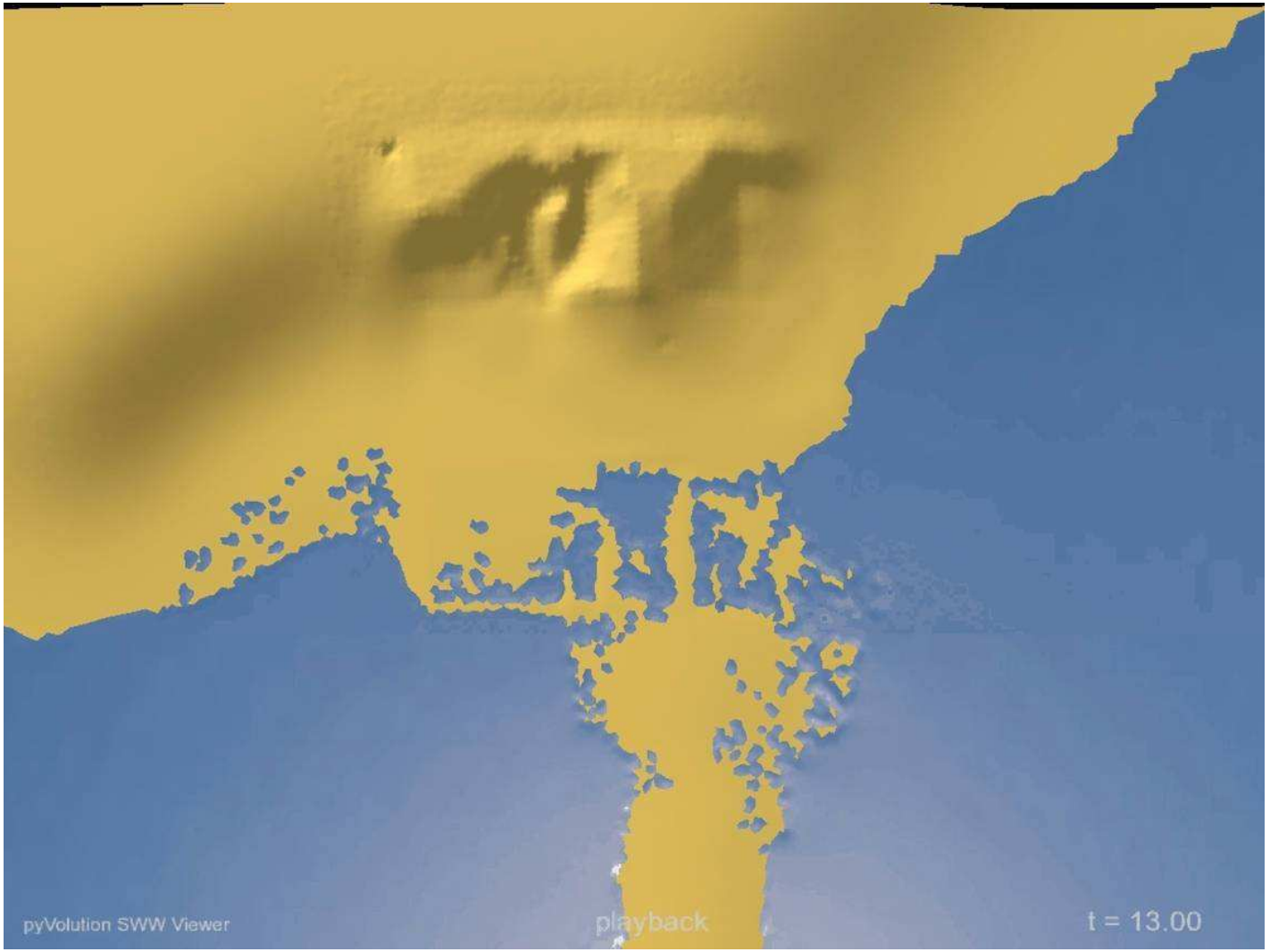

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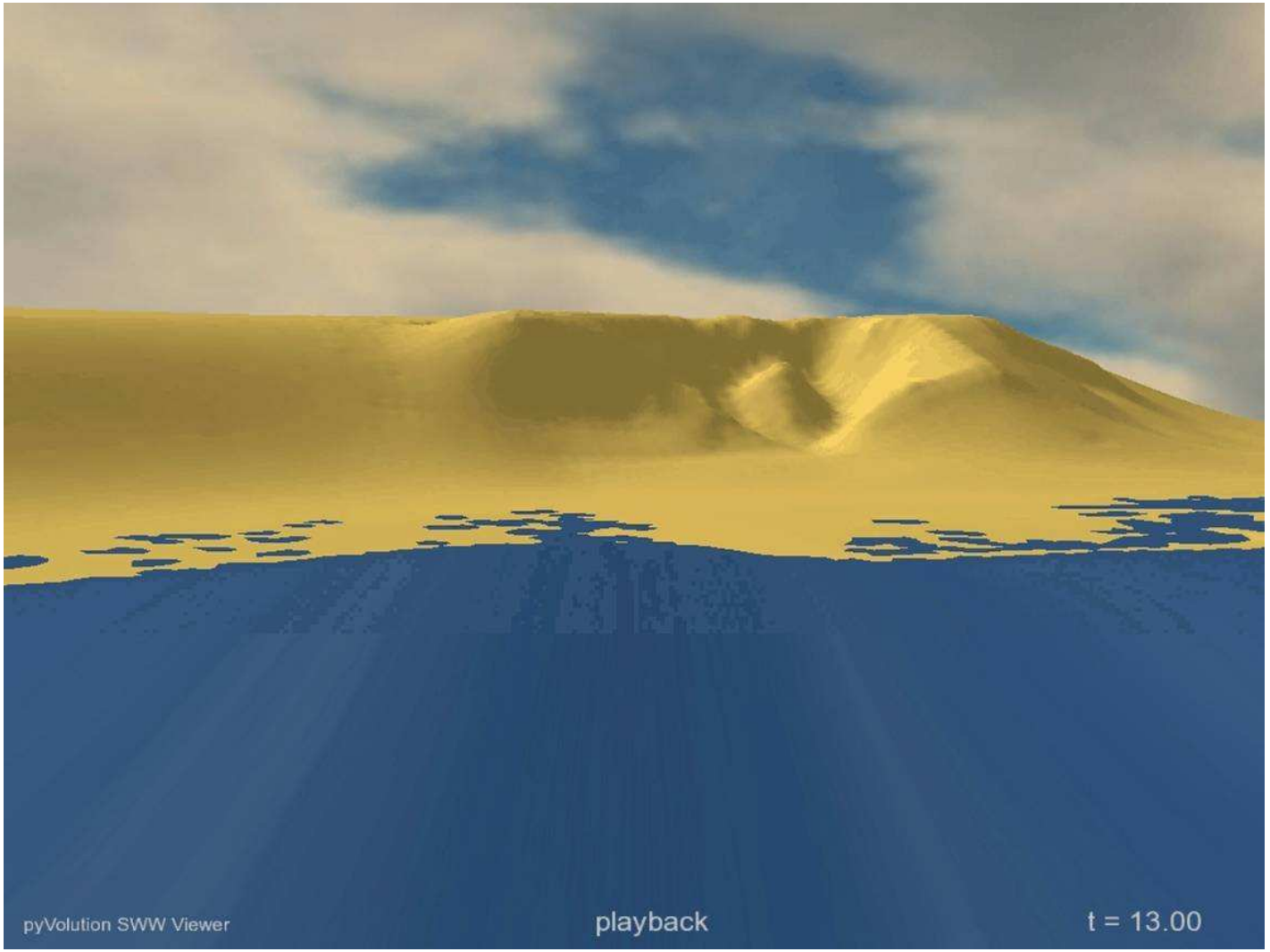

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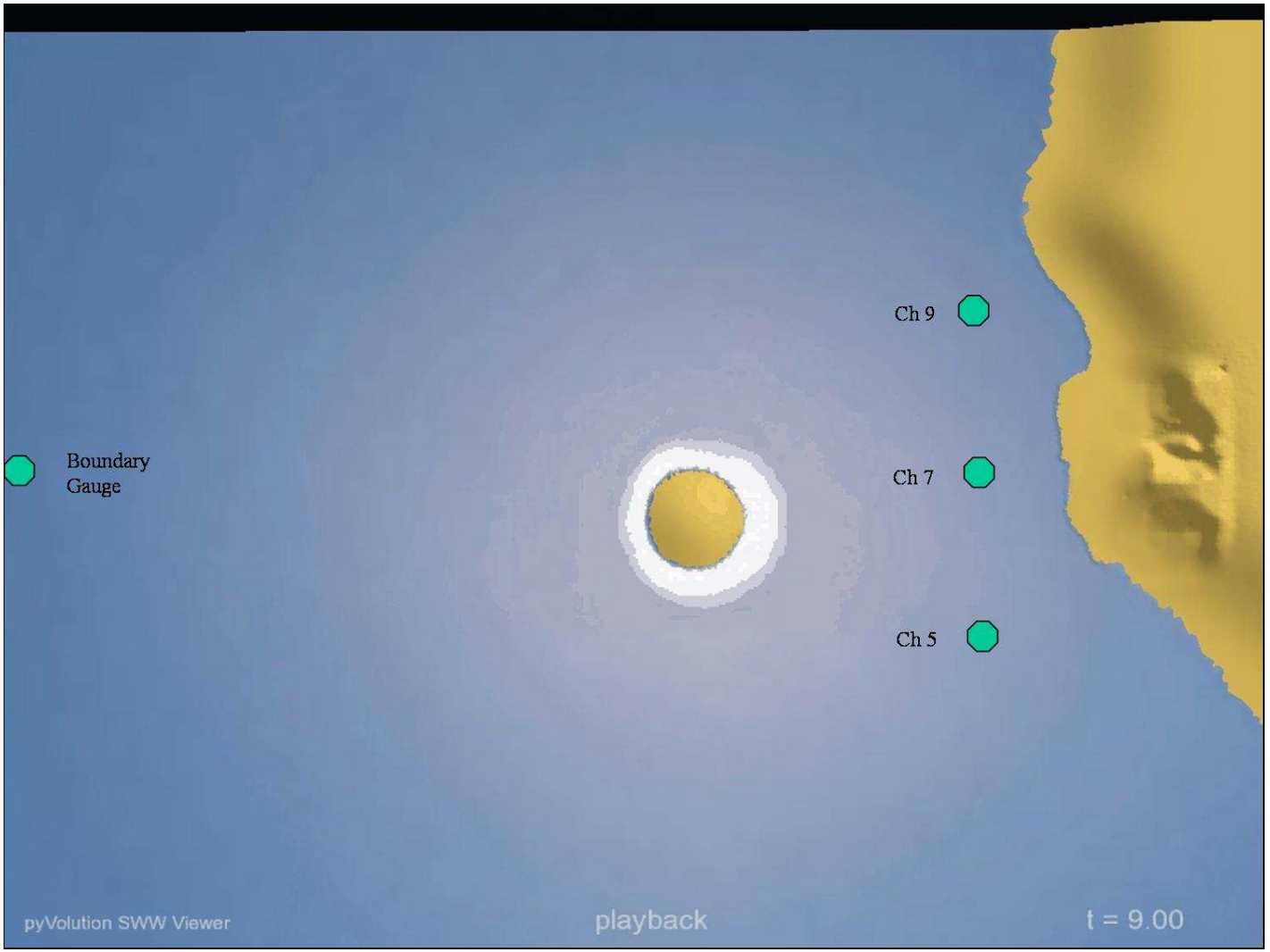

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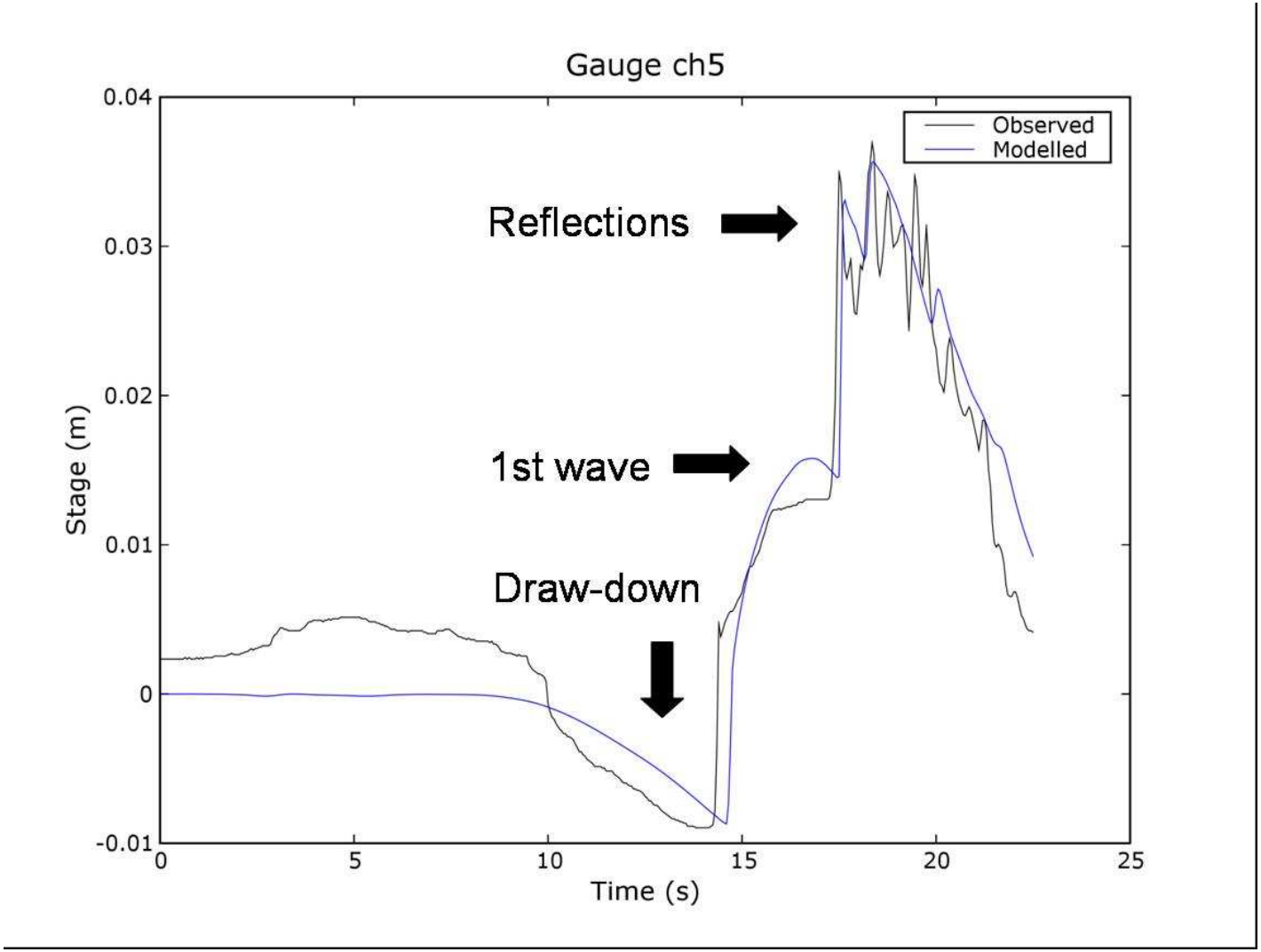

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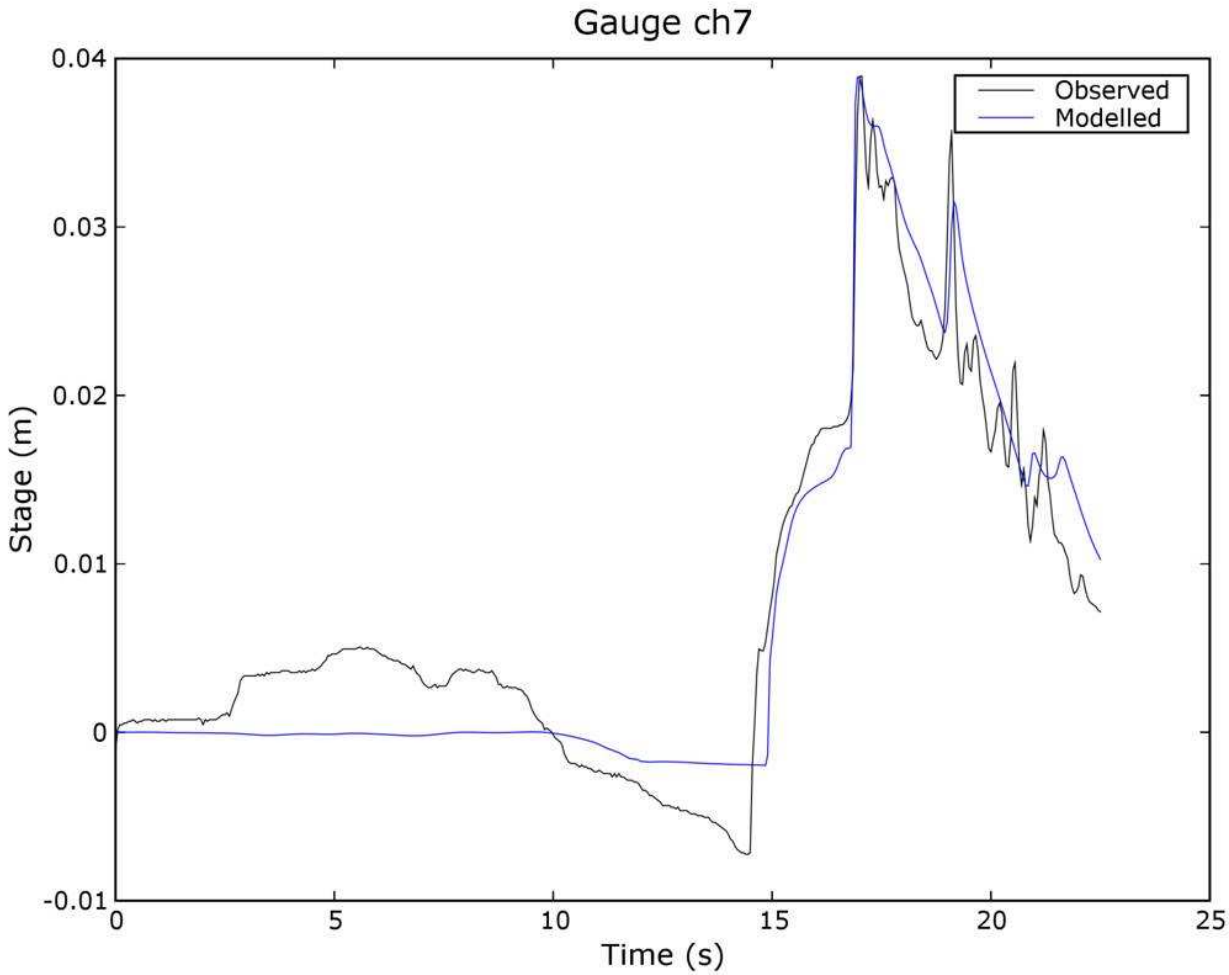

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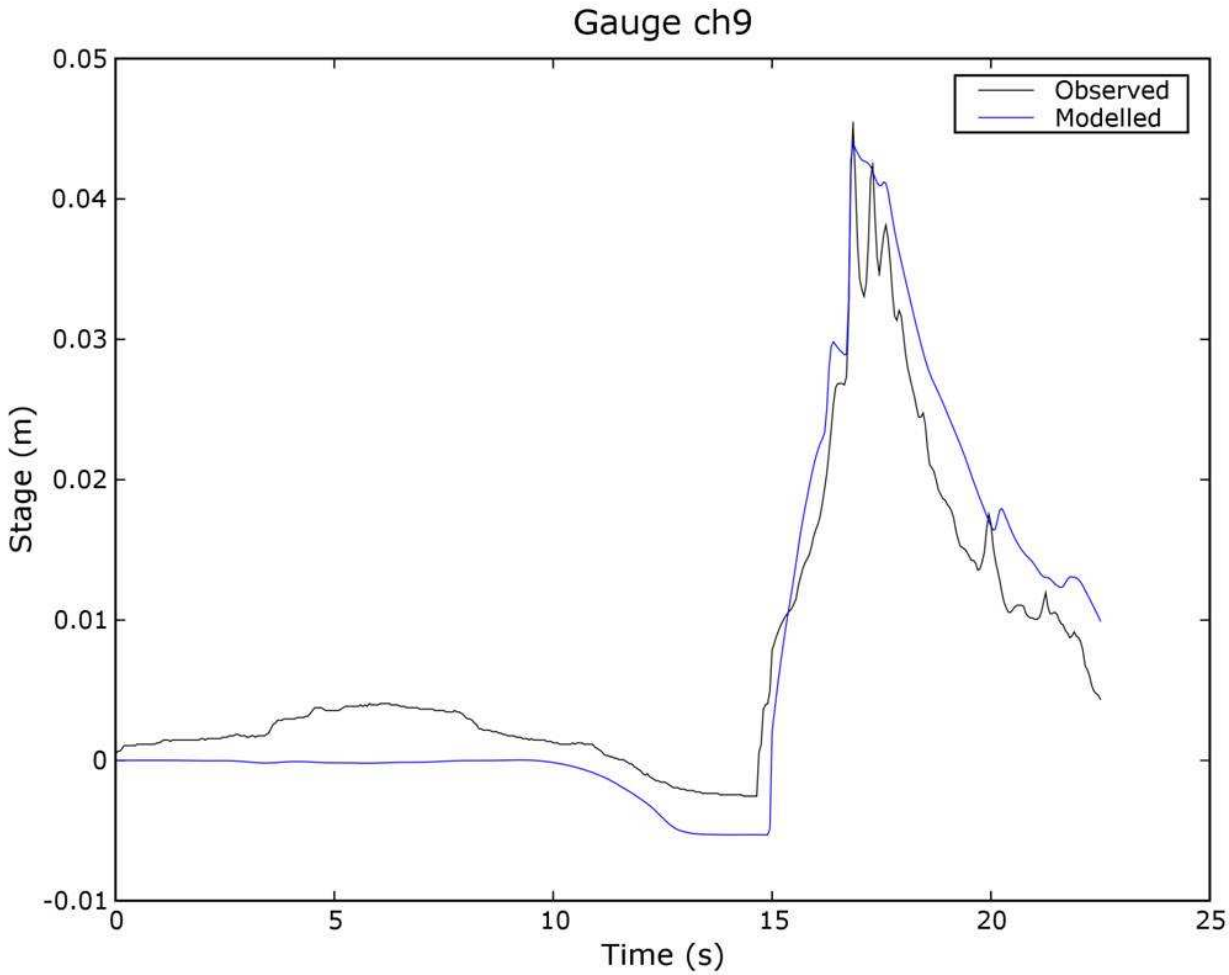
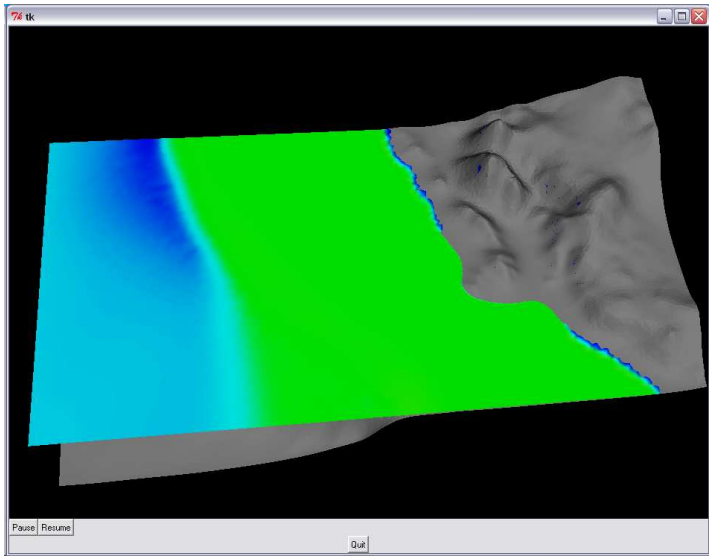
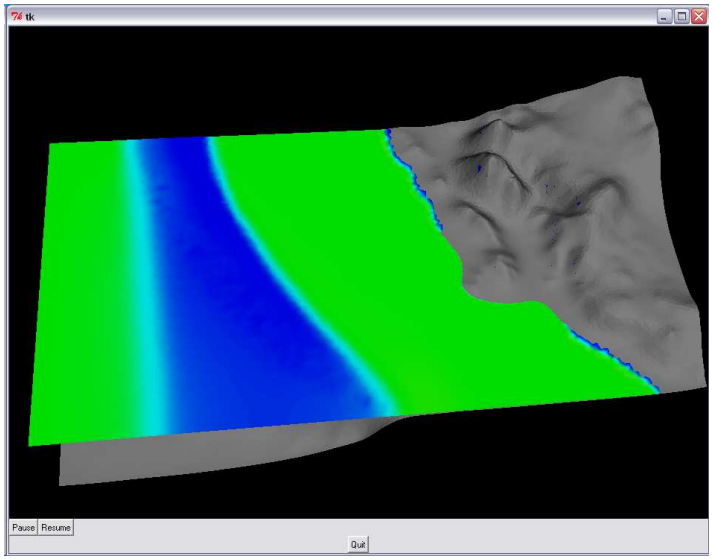
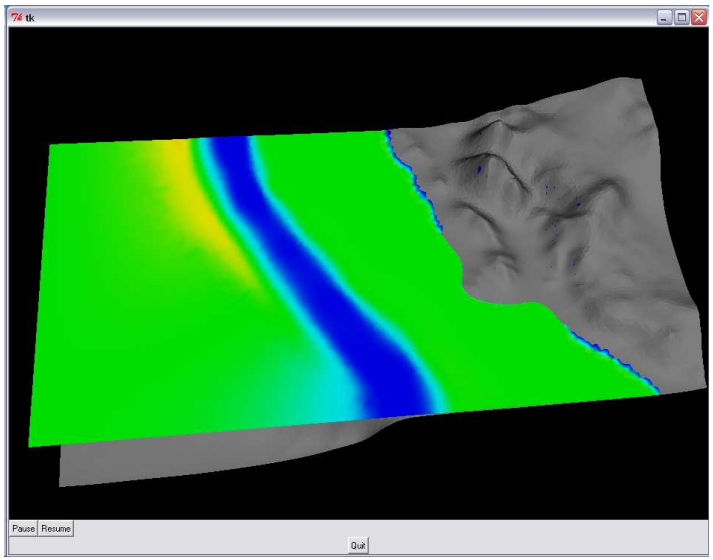
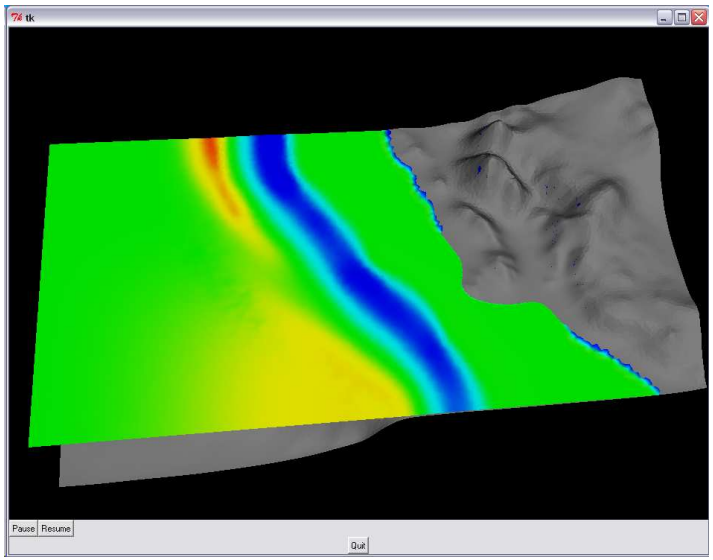


Queensland Coast Simulation









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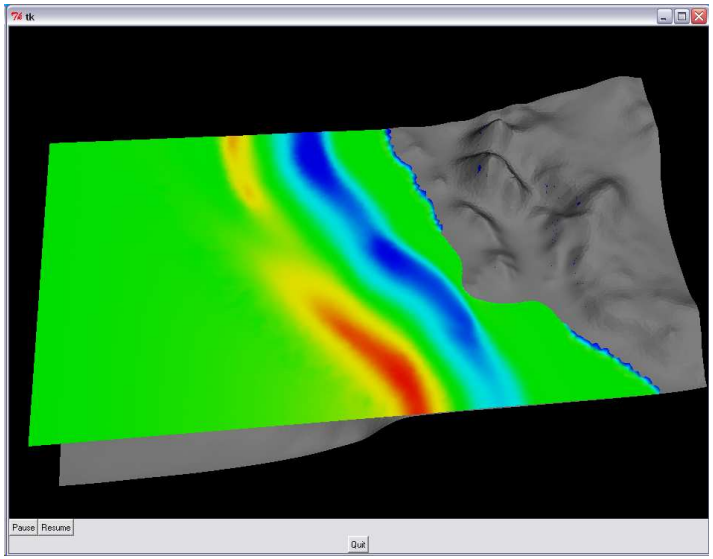

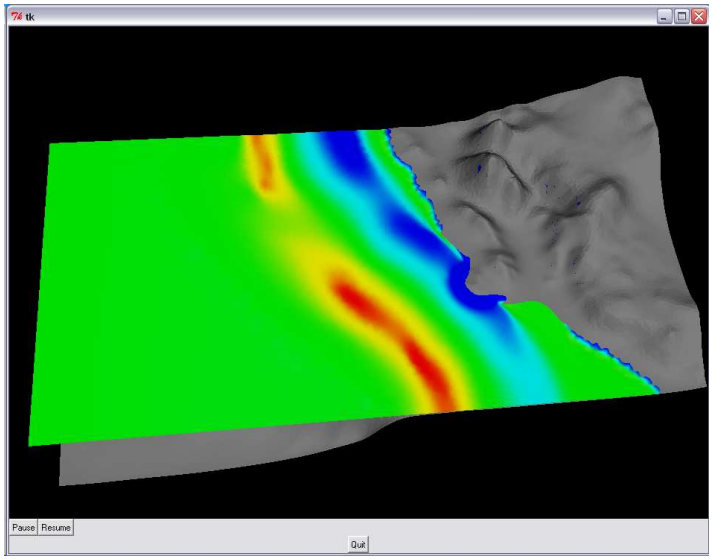

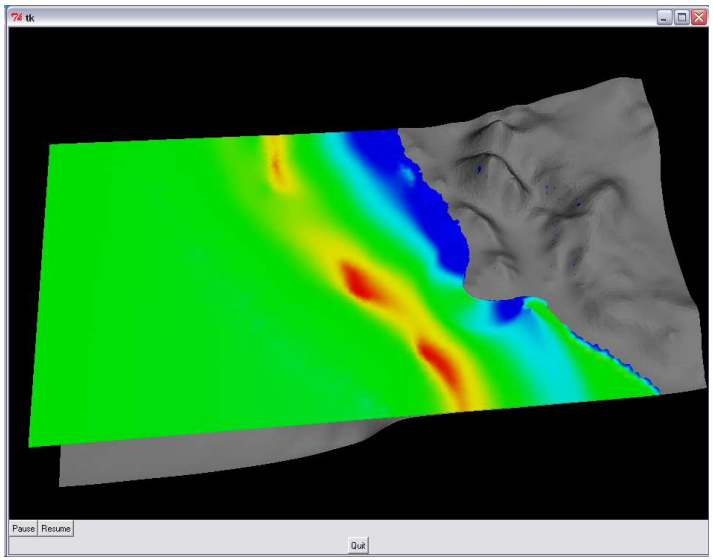

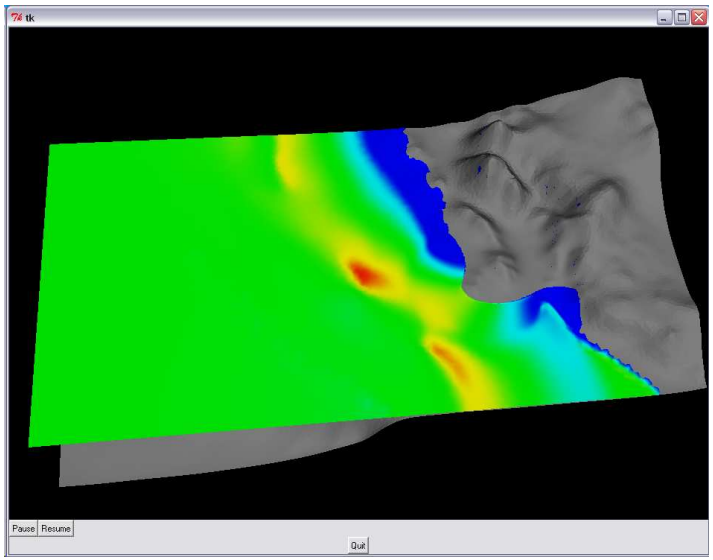

Future Work and Collaboration

- Streamline software and data flows to improve efficiency (esp. linkages to spatial data and other models).
- Technical documentation, user manuals and a formal open-source release.
- Tsunami inundation modelling in Western Australia by new GA staff funded by FESA (initially Karratha).
- Acquire complete datasets for:
  - Boxing day tsunami scenario
  - further model validation
  - support of the ATWS and Australian Risk Map
- Handling uncertainty (with ACFR)
- Finish parallelisation work
- Refinement of numerical schemes (2 order, implicit schemes, geographic grids)