ANUGA Workshop, 16 - 17 September 2008
Geoscience Australia

Workshop notes

Participant list

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Day 1, 16th September 2008

Discussion
Tsunami modelling requirements

Boussinesq terms
General comments:
- Likely to be expensive
- Waves would look more realistic
- Maybe not that important, but definitely could be done
- Similar to viscosity in terms of work
- Third order reconstruction would provide higher accuracy but probably not be worth it by itself. However, it might pave the way for the Boussinesq terms.

Friction
General comments:
- Macro-roughness discussed
- John Murtagh: This will depend on whether houses fill up (which they do)
- Rudy Van Drie: Film clip shows how water outside the house would move much faster than inside
- Runs with solid buildings and without buildings provide envelope or bracket around the range of uncertainty.

Validation
General comments:
- Where the water goes is about right.

Implicit/semi-implicit scheme
General comments:
- Not clear if implicit time stepping is worth the effort.
- Expensive and requires global communication
- Gary Tong: Maybe a semi-implicit approach would be good?
- If kinematic viscosity was to be implemented (global system solved anyway) then perhaps it would make sense to implement an implicit scheme.

Speed
- Run time of 24 hours is the goal
- Need: Speed, Accuracy, Stability (+ user friendliness and flexibility).

General comments:
- Macquarie Rivulet takes about 2 days with Tuflow and 5 days with ANUGA
- Parallelism will help.

Damage assessment
General comments:
- William Power: Building vulnerability is more important to GNS (than erosion)
- How to account for buildings and vulnerability is important. Buildings can collapse and large velocities appear between buildings
- Uh-maps times debris factor is often used as damage measure (Ainslie?)

- More work on parametric hazard algorithms is needed. Rudy Van Drie suggested d + uh or d + u^2/(2g) as much better than uh. Still water is dangerous but not reflected in uh.
- This can easily be implemented as parametric equation in sww2dem
- Steven Roberts: Need Robust velocity field calculation, discontinuous beds which will also lead to better representation of buildings.

Other hazards

General comments:

- The ANUGA architecture may potentially provide a platform for erosion/deposition.

Participant written answers to the question:

Please provide brief dot points to document where you would like to see any future development of ANUGA for tsunami. For example, please consider additional features, enhancements or functionality, modifications to existing features and functionality, issues which you would like to see resolved etc. Many issues may be generic for many hazards (e.g. GUI).

Installation

- First facing many problems with installation routines under Fedora, but changing to Ubuntu brought much improvement, debian package of ANUGA
- Simple installation
- Installation instruction might need to be reviewed, particularly noting either python 2.5 or 2.4 can be used
    - Some links don't seem to work on pdf and some are broken
- Could be an error in validation of Okushiri. Is Okushiri.msh in the download or have I not the read the instructions properly?

Parallel

- Code suitable for scale corresponding to our project domain, but single CPU computations for domain are time consuming
- Using/even installing parallel version is still tricky → maybe more documentation available?
- Parallel implementation please
- Parallelisation tested and deployed.

Mesh

- Using house masks: add_hole_from_polygon doesn't work
- Sometimes too small triangles (degenerate triangle) → method to get rid of them beforehand?
- Automatic removal of very small triangles
- Donuts polygons
- Automatic change in maximum triangle size with depth when mesh is generated
- Automatic polygon automation based on elevation contours
- Mesh tools would be very useful
    - Mesh tool from River2D could be used with ANUGA.

Amendments

- Sometimes we observed a strange loss of the complete water in domain?
- Error checking/mass balance errors
- Better error reporting
- More guidance on alpha value
- Investigate potential instability in set_stage_transmissive_boundary.

Evolution

- File size of 2GB not sufficient.

Post-processing

- GUI would be of interest only for pre/post-processing
- Visualisation (wave height, wave direction, water depth, etc)
- Data extraction (wave spectra, velocities, etc)
- Colour contours
- Pretty pictures! i.e. make it easier to produce images of inundation, time series, etc directly out of ANUGA
- View changing bathymetry in ANUGA's viewer
- View velocity vectors etc.

Additions/functionality

- Implementation of weirs (Sharp/broad crested weir, undershot sluice gates, etc.)
- Mannings and buildings
    - macro-roughness law to get rid of houses
    - test sensitivity with and without building (new)
    - Rethink Manning's n approach
    - Forces on buildings, i.e. some fail, some survive, change roughness
    - Realistic representation of building would be very worthwhile
    - Is Manning's n is sufficient to model the losses and wave attenuation once the tsunami reaches shore?
    - Effect if house is destroyed
- Include tsunami transformation (diffraction, breaking, dispersion, etc)
- Include tide offset
- Inclusion of 3rd derivative, Boussinesq terms may (should) increase the performance envelope of the model, particularly where the flow departs from "nearly horizontal". There will be a computational cost to pay.
- Is it possible to contemplate 3rd order accuracy spatially (lots of things have been said e.g. ghost triangles which suggest it may be difficult). Also 2nd order accuracy in the time-stepping. (SR: Third order reconstruction may not be worth it by itself but might pave the way for the Boussinesq term).
- Computational effort remains a concern. Is it possible to consider an implicit algorithm (SR: not clear if implicit time algorithm is worth the effort. Expensive but can be done. GT: Maybe a semi-implicit scheme would be useful? Will dig out a paper which may assist)
- Can we track the maximum inundation over model simulation time? i.e max water level contours
- Measure of time wet at an onshore location, provides a measure of vulnerability
- Area of inundation area in a polygon and clipped to coastline

- Couple export_results with ESRIGRID
- Flux function for area around dry-bed and discontinuous bed
- Linear mode to compare with URS and understand depths where nonlinear is required
- Standard wave forms and methodology to develop wave trains
- Energy dissipation of breaking waves
- Coordinated approached publication of sensitivity/convergence testing
- Kinematic viscosity (particularly at entrances or where shelf is irregular)
- More validation
- Faster computation
- Depth varying roughness capability
- Use spherical coordinates to allow ANUGA to be used for propagation tool
- Changing elevation with time
- Destruction of dune with first wave.

Documentation and training
- Map of ANUGA's architecture and dependencies
- Tutorial workshop.

General
- Wikipedia page.

Other hazards
- Storm surge
- Beach erosion. RV: Affect of sea level rise and climate change. People talking about but no solution yet. ANUGA may help to fill this space.
- Incorporate XBeach geomorphic code into ANUGA
- Flood validation
- Weirs, culverts to model propagation of flood water across land.

New
- Greater uncertainty in urban areas due to affect of buildings. Affect of debris on water flow and damage.
- Computational time a large concern for flood (as other commercial flood models available). (RV: Adaptive meshing could be useful)
- Flood: Couple 1D with a 2D model could help save computational time.
- Impact of velocity – evacuation of people
- Paucity of flood damage data. How much force does it take to destroy different types of buildings. CSIRO work on flood forces – came up with an adaptation of the wind code. Available through NSW SES Floodsafe website.

Top priority identified verbally by participants:

- Nils Goseberg: How to account for buildings
- Rudy van Drie: Speed
- Trevor Dhu: More validation
- Ole Nielsen: Speed
- Leharne Fountain: Improve mesh utilities

- James Walker: Presentation output
- Jasvinder Opkar: Visualisation
- William Power: Improving what happens in urban areas
- Biljana Lukovic: Same as Will and Nils
- Ainslie Frazer: More validation
- Gary Tong: Speed
- Jonathon Griffen: Same as Nils
- Steven Roberts: Robustness of underlying algorithm
- Russell Blong: Better definition of roughness
- Geoff O'Loughlin: Speed and accuracy
- Duncan Gray: Documentation of current capability
- Nick Bartzis: Mesh represents change in DEM
- Brad Weir: Documentation on sensitivity and convergence
- Richard Mleczko: Validation
- Sudi Mungkasi: 1D ANUGA, discontinuous bed
- David Burbidge: non UTM - would like to model from source to sink
- Kristy Van Putten: Output – Straight to ARC.
- Jane Sexton: Robustness in the parallelisation

ANUGA workshop
Day 2, 17th September 2008

Discussion
Flood modelling requirements

The general consensus reached was that stability is a key asset of ANUGA. It was agreed that while other software may have much quicker run times, significantly more time may be spent on achieving stability in those runs.

Ian Dinham
Flood modelling needs revolve around:
- Development Control
- Models simple enough to be used by regular local government staff, otherwise it just becomes another tool for consultants to use.
- ANUGA would need to demonstrate clear advantages over other models to be considered. Suggest large catchment (>200km^2) comparison between ANUGA and e.g. Tuflow.

John Murtagh
- Coastal interfaces (Effects on floods from combined storm surge and rainfall)
- Desirable to have flood modelling toolkit with much functionality yet an option for simplicity depending on the end user.
- Near bed velocities needed for erosion. Does a 2D model provide that?
- Erosion is likely to used only locally due to e.g. computational constraints and model objective.

<u>General comments:</u>

- Most existing models have difficulties with shallow sheet flows but it is easy with ANUGA to work out where the water will flow. Very useful in urban areas.

Rhys Hardwick Jones
- connection with drainage model
- allow input of structures (may affect the stability)
- validation so that the level of uncertainty is understood with each component
- kinematic viscosity
- love being able to code things in themselves
- evaporation, crop, soil interactions
- training
- GUI

General comments:
- ANUGA seems to fill a gap. It is different to other models (moving boundary, robustness, flexible interface etc…)
- Open data formats and open source is important
- Estuary process would require coupling between Coastal and River environments. ANUGA might be useful here.
- 1D-2D interfaces could be achieved due to the inherent mass balances in ANUGA
- Need for ALS suppliers to educate the owners of the data that they supply.

Soori Sooriyakumaran
- Exploit linkage between hydrological and hydraulic models (e.g. WBNM & ANUGA)
- Using multiple models may reflect uncertainties.
- ANUGA could be used to cross check other models
- There is a need for 'hot starting' (checkpointing) – e.g. helpful in flood forecasting
- Good to be able to use in real time.

General comments:
  - There will always be a number of software models available for use. ANUGA can be another model for the toolkit.
  - Big assistance in modelling flash floods.

Geoff O'Loughlin
- ANUGA training covering the essentials and pitfalls. The provision of worked through example is important.
- Improve the ease with which the software is installed to make installation as easy as possible.

Gary Tong

General comments:

ANUGA is unique:
- Wetting/drying
- Shocks and patterns
- Sub- to super critical transitions
- Having dealt with the 'moving boundary problem'
- Riemann solver (invariance?)

- Amazing wave formulations
- Interactions with upwellings
- Conjunctive flows
- Ideal for designing flows such as those at the white water stadium.

Rudy van Drie
General comments:
- Anuga could be used as a teaching tool
- The Water Authorities in Germany pay consultants to build models but the actual models (and the software) are kept in-house.
- River 2D – free, has a mesh builder, which can be used to refine meshes, but unlike ANUGA it is very unstable.

Steven Roberts
General comments:
- Wary about plugging in new modules because of the potential affect that it may have on stability.
- Viscosity is probably OK to add, but will result in slower runs, possibly in the order of 5 times slower.

Participant written answers to the question:

Please provide brief dot points to document where you would like to see any future development of ANUGA for flood. For example, please consider additional features, enhancements or functionality, modifications to existing features and functionality, issues which you would like to see resolved etc. Many issues may be generic for many hazards (e.g. GUI).

Installation/Training
- Animate.exe under Linux (as source or package)
- Training material – short examples showing data preparation with GIS, ANUGA operation and views of results (eg flow through street intersection)
- Getting Started Document (simple step by step procedure setting up example models)
- Installation package for Ubuntu/Linux
- Simple installer for Windows XP Vista in the future
- Publish list of supporting software used to produce ANGUA models.

Validation
- Testing hydrology against hydrologic models and real world gaugings where available
- Some "sanity checking" of velocity results appear to be required, especially if velocity results are to be used to calculate and report hydraulic hazard
- Flood validation as part of the validation suite
- Would be really nice to see some calibration/verification results or even more comparison to existing models.

Tools/Pre and post-processing

- QGIS Interface development (free GIS)
- Hydrology (rainfall/runoff) tools
- As others have noted, a GUI for model setup would be helpful, although this may be effectively achieved by easy input of standard GIS formats
- Automatic Mesh Refinement by either Defining polygons from wet region
    - Or Full adaptive Meshing
- Mesh tools (automate ability to create polygons around a set depth to refine the mesh)
- A front end (user interface) to assist in making it more user friendly
- Easily understandable front end working in Windows Vista (as well as XP and Linux)
- ANUGA viewer able to view depth, velocity etc
- Linux viewer
- Use ecw images as textures
    - Screen grabber to create AVI or WMV movie files from animate.

Amendments

- Error when using *.asc grids having '|' instead '.' Delimiter
- Variable rainfall input but limited to polygon
- The ability to add a discharge hydrograph across a line would be highly desirable. It may be necessary to assume a velocity if no better method for distributing the flow can be found
- Would like to see how it performs for larger catchments (> 1000 km2 say)
- Computational speed.

Interaction with other models

- Coupling with Hydrologic Model, so that very large catchments can be modelled with a hydrologic engine doing most of the work and specific 2-D models. EG: Murray River in Hydrologic Model, Towns in 2D model
- Coupling 1D river flows to 2d ANUGA
- Eventually, coupling to a 1d drainage model would be great (essential for when modelling in many cases)
- Integration of ANUGA surface flow modelling with pipe systems model (SWMM5, DRIANS, etc).

Increased functionality

- Kinematic viscosity formulation should be a high priority
- Include dynamic viscosity to code
- Handling of changed circumstances during a run (e.g. washout of a levee, dambreak, priming of culverts, collapse of a wall)
- Infiltration
- Difficult to see if used in conjunction with flood modelling in a stochastic approach in which thousands of Monte Carlo trials are required
- Velocity profile (uniform profile)
- Need to include turbulence, particularly in the vertical, Mark approach.

Hazards

- Landslips

- Debris flow
  - Integration with Titan2D?
  - Include terms in ANUGA?
- Pyroclastic flow
- Flash flood
- Storm surge
- Riverine flooding
  - Cyclone track used
- Erosion/deposition capability (riverine, coastal)
  - Add standard erosion equations (~ 12)
  - Create ability to use hybrid of equations
  - sedimentation transfer/transport – sediment equation written in probability form. Test for resuspension based on random number. Stochastic approach to sedimentation
  - sediment deposition
  - resuspension
- Plume modelling
- Water quality/disaster planning
- Ability to plot results of Parametric equations to identify new definition of hazard (eg: (Dx(1+DxV) etc..
- Dam break
- Design of structures e.g. culverts, buildings, bridge piers.

Terrain

- Can the TIN be exported/imported for use in other software such as WaterRide Flood Manager & 12d.
- Best way to integrate survey data and ALS data so that break lines etc are retained. At the moment this can be achieved by using poly lines (ungenerate files?), but this does not works properly.
- Thinning or decimation of ALS data, what should we be using?
- Auto refine of mesh, ie start with course mesh and ANUGA calculates extents (first pass course run) and then fines mesh up around flood extent poly.

Structures

- What about weir opening changing by time
- Include ability to model impact of piped drainage system (1d underground system)
- Pressurised flow for bridges (include ability to model bridge decks)
- Need for underground pipe systems with surcharging
- Bridge failure/embankment failure
- Have the option to use a rating curve to model structures instead of the current routine to speed up processing time.
- Multiple culverts cause instability in processing.

Buildings

- Can buildings be added as 3d shapes so they can be added or removed individually?

- Can the buildings be refined so that the edges are straight (i.e. not affected by the mesh size)
- Can the buildings have flat tops (or gabled), rather than just the terrain extruded up?
- Example of the ESRI ungenerate file format is used. Possibility of using AutoCAD dwg, ESRI shp or Map Info mid/mif formats.

Application of rainfall (vertical forcing function)
It is very important to recognise the imitations of modelling direct rainfall on the domain, rather than the traditional approach of deriving flows from a hydrologic model. We have undertaken research which indicates results can be inconsistent and highly sensitive to assumed model parameters

- The ability to allow the model to run to the user specified end time step without it stopping when the rainfall end time step is reached. This would be good because rainfall temporal patterns are of a specific length (eg 2 hours). When we run the model, runoff is generated past this time because water is running off the catchment. When we run a model now, we have to specify how long the model continues to run after the rain has stopped falling. If the rainfall file does not go past this time, the model stops. So the ability for the model run script to override the rainfall forcing functions would be good. All that we need to tell ANUGA is that if it sees that the final time step is greater than the final time in the rainfall file, to just continue running to the final time step and to apply 0 rainfall.
- Script to apply soil losses to rainfall. Pervious and impervious areas for Greenfield sites. Urban or Industrial too hard?

Customisation of the viewer

- Display the current vertical exaggeration.
- Can the display retain brightness when vertical exaggeration is increased (as it currently gets darker if vertical exaggeration is used)
- Change the vertical exaggeration whilst running
- Switch to 2d view
- Query the RL from the terrain, water level, velocity, x/y coordinates etc
- Query rate of rise at a point
- Query flow along a polyline
- Switch between aerial photo/topo/no backgrounds
- Can vector information be overlayed as well as imagery? E.g. road centre lines and street names
- Ability to view applied roughnesses (coloured polyies) and structure locations
- Icon of the viewer for easier association in windows and associate sww files
- Viewer for Ubuntu (Linux)?
- Flow arrows to show direction of flow.

Results/Output files

- output from sww files at the moment has too many decimal places. There is no need for this in flood modelling. Two decimal places matches the accuracy of the supplied data. This will save file size and computing power.
- Iteration of time steps, extraction of peak flows, velocities, rate of rise (depth versus time) etc.

Top two priorities identified by person

- Geoff O'Loughlin: Speed, maintain stability when new functions are added
- Nick Bartzis: Automatic mesh generation, mesh based on parameters of interest e.g. depth. Allow visualiser to colour code based on depth and/or velocity
- Rhys Hardwick Jones: Inclusion of pipes, better documentation, user interface
- Russell Blong: Forces on structures including buildings, combined (storm) surge and riverine flood
- Brad Weir: Better idea of convergence and understanding model sensitivities to mesh resolution, quality measures, combined surge and riverine flood
- Nils Goseberg: Parrallelisation, improvement in pre/post processing, sediment transport
- John Murtagh: Validation/calibration against historical data (need to identify catchment with good pluvios, river gauges etc): test small catchments with direct rainfall on catchments and big catchments with hydrographs. See value in using Penrith white water stadium as example of synthetic data large enough to be relevant.
- Ainslie Frazer: same as John, could look overseas for data; more calibration/validation against direct rainfall, inclusion of structures
- Steven Roberts: Momentum sink (not just friction), Boussinesque terms, viscosity, structures
- Garry Tong: Semi-implicit formulation, sedimentation capability (stochastic approach)
- Jane Sexton: Validation: making available benchmark problems; parallelism
- Biljana Lukovic: Validation, inclusion of structures including buildings, better documentation (its capabilities are not clear)
- Will Power: Automatic mesh generation, mesh based on parameters of interest e.g. depth, topography
- Ian Dinham: Validation (using both physical data and comparisons to other models); combined surge and riverine flood, GUI to make more accessible to local government.
- Soori Sooriyakumaran: Hot-starting, levee failure from overtopping; run in real time (for flood forecasting), storm surge
- Ole Nielsen: Simplicity in model building (e.g addition of culverts or buildings); Validation datasets and associated codes available online so that it can be reproduced
- Rudy Van Drie: Piped network (prefer built into ANUGA suite); viscosity
- Craig Palmer: Breaklines included in meshing algorithms to assist with refining mesh; make installation easier.
- Petar Milevski: Better extrusion tools (e.g. of a building); autorefine of mesh
- Matthew Apolo: Piped network; more user friendly e.g. improvement to manual (look at Tuflow manual)
- Miriam Middelmann: Forces on structures (water pressure on buildings, debris, including impact of building failure downstream etc). Increase accessibility (e.g. GUI, improvement in installation manual)
- Trevor Dhu: Validation, better documentation (Rhys: Tuflow is a good example).