Title: Robust Computational Models for Water Waves

Abstract:

The development of accurate and robust computational models for water waves is vital for the assessment of natural hazards such as tsunamis, storm surges and rogue waves. It is also essential for understanding many other related physical phenomena such as beach erosion, nutrient transport in marine environments and the break up of sea ice at the poles.

Previous work at the ANU in this area has included a collaboration with Geoscience Australia to develop ANUGA, which uses the Shallow Water Wave Equations (SWWE) to model water and has been applied to riverine floods, tsunamis and storm surges. However, as with all mathematical models the SWWE make some assumptions that limit their applicability as the length of waves relative to the depth of water decreases. These assumptions mean that SWWE have no wave dispersion and so the speed of waves is independent of frequency. Recent papers have shown that dispersion has a significant impact on wave height for tsunamis; particularly far from the source [1,2]. Therefore, a new model of water waves that includes dispersion is necessary for accurate tsunami modelling and the inclusion of these effects could also be important for other water wave phenomena.

This lead to the current research at the ANU to develop numerical methods for the Serre equations, a set of dispersive equations that are considered to be one of the best models for water waves up to wave breaking. As part of this work Chris Zoppou completed his PhD in which he developed and validated a numerical method that appeared to handle steep gradients in the flow very well and contained variable bathymetery [3].

I have continued this work by; rigorously demonstrating the validity of of numerical solutions for steep gradient problems [5], performing a linear analysis on our numerical methods demonstrating good convergence and dispersion properties [4] and extending our numerical methods increasing their robustness and allowing for dry beds.

References:

1. J.T. Kirby, F. Shi, B. Tehranirad, J.C. Harris, S.T. Grilli, (2013), Dispersive tsunami waves in the ocean: Model equations and sensitivity to dispersion and Coriolis effects, Ocean Modelling, 62.

2. Kulikov, E. (2006), Dispersion of the Sumatra Tsunami waves in the Indian Ocean detected by satellite altimetry, Russian Journal of Earth Sciences, 8.

3. C. Zoppou. Numerical Solution of the One-dimensional and Cylindrical Serre

Equations for Rapidly Varying Free Surface Flows. PhD thesis, Australian

National University, Mathematical Sciences Institute, College of Physical

and Mathematical Sciences, Australian National University, Canberra, ACT

2600, Australia, 2014.

4. C. Zoppou, J. Pitt, and S. Roberts. Numerical solution of the fully non-

linear weakly dispersive Serre equations for steep gradient flows. Applied

Mathematical Modelling, 48:70–95, 2017.

5. J.P.A. Pitt, C. Zoppou, and S.G. Roberts. Behaviour of the serre equations

in the presence of steep gradients revisited. Wave Motion, 76(1):61–77, 2018.