

3. Modelling tsunami inundation

3.1. Model grid – topography and bathymetry

Model grids were developed for the two source scenarios. For the distant source (South America) a refined version of the EEZ grid was used (see Figure 2). This grid spans from approximately 157 to 210 degrees east longitude and 22 to 65 degrees south latitude. Another grid was developed for the Tonga-Kermadec source from just south of East Cape to 22 degrees south latitude. Both of these grids were refined in the areas of interest around the Northland coast (see Figure 3). Bathymetric data were derived from a number of sources. For the EEZ area, existing data were used. Digitised RNZN Bathymetry charts were used for various bays and harbours. Local inundation grids were created for the fifteen areas listed above. The coastline around these locations was further refined to a resolution of around 20 metres and a land grid was created for each area. The topography of the land grid was taken from LIDAR data provided by NRC. This data is referenced to One Tree Point in the vertical, which was assumed to be approximately mean sea level for the entire coast of Northland. This assumption was justified by surveying done by NRC (Bruce Howse, *pers. comm.*).

The finite element model grid has a number of requirements to ensure that model calculations will be accurate and free from excessive numerical errors (Henry and Walters, 1993). The primary requirements are that the triangular elements are roughly equilateral in shape and their grading in size is smooth from areas of high resolution (small elements) in the coastal zone and on land grids to areas of low resolution (large elements) offshore.

The grid was generated using the program GridGen (Henry and Walters, 1993) according to the requirements described above. Layers of elements were generated along the boundaries using a frontal marching algorithm (Sadek, 1980). Interior points were filled in using the cluster concept described in Henry and Walters (1993). The grids were then refined by a factor of four by subdividing each grid triangle into 4 new triangles using vertices at the mid-sides of the original triangle. This refinement was continued until the target resolution was obtained. Once a satisfactory computational grid was created and quality assurance test were performed, water depth and land elevation values were interpolated at each node from the above reference datasets.

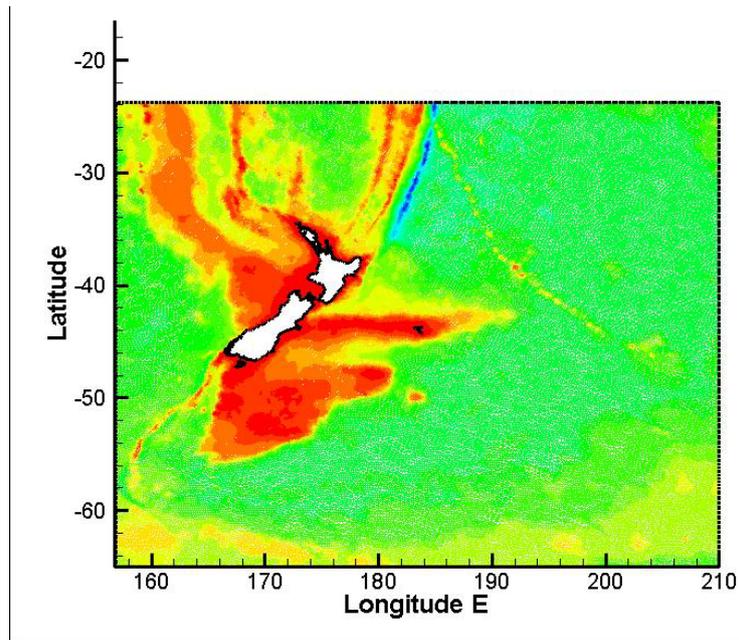


Figure 2: Far-field Tsunami grid. Colour represents water depth. Denser colour shows extra refinement of elements in shallower coastal areas and areas of rapidly changing bathymetry.

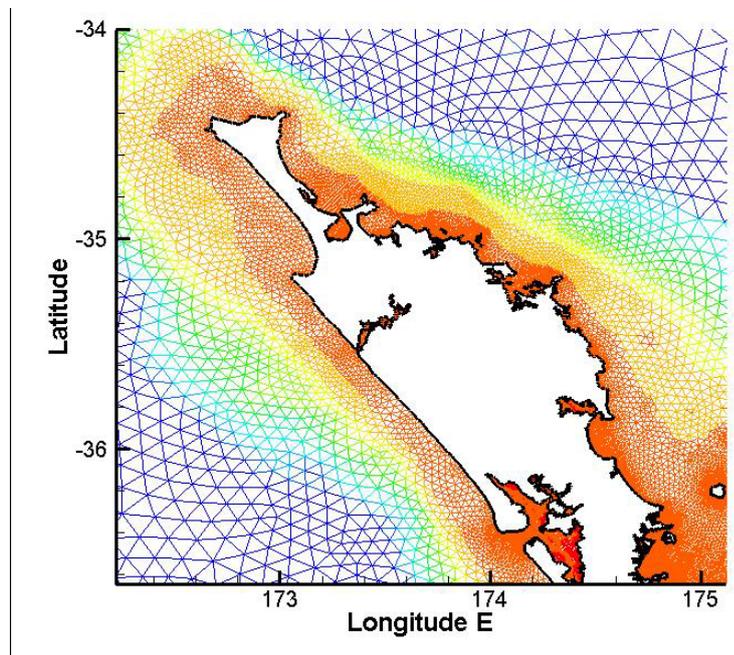


Figure 3: Close-up of the grid around Northland. Colour represents water depth. The size of the elements can clearly be seen to grade in towards the complex coastline.

3.2. Numerical model

The numerical model used in this study is a general-purpose hydrodynamics and transport model known as RiCOM (River and Coastal Ocean Model). The model has been under development for several years and has been evaluated and verified continually during this process (Walters and Casulli, 1998; Walters, 2005; Walters et al., 2006a; 2006b). The hydrodynamics part of this model was used to derive the results described in this report.

The model is based on a standard set of equations - the Reynolds-averaged Navier-Stokes equation (RANS) and the incompressibility condition. In this study, the hydrostatic approximation is used so the equations reduce to the shallow water equations.

To permit flexibility in the creation of the model grid across the continental shelf, finite elements are used to build an unstructured grid of triangular elements of varying-size and shape. The time intervals that the model solves for are handled by a semi-implicit numerical scheme that avoids stability constraints on wave propagation. The advection scheme is semi-Lagrangian, which is robust, stable, and efficient (Staniforth and Côté, 1991). Wetting and drying of intertidal or flooded areas occurs naturally with this formulation and is a consequence of the finite volume form of the continuity equation and method of calculating fluxes (flows) through the triangular element faces. At open (sea) boundaries, a radiation condition is enforced so that outgoing waves will not reflect back into the study area, but instead are allowed to realistically continue “through” this artificial boundary and into the open sea. The equations are solved with a conjugate-gradient iterative solver. The details of the numerical approximations that lead to the required robustness and efficiency may be found in Walters and Casulli (1998) and Walters (2005).