TSUNAMI INFORMATION FOR NORTHERN TERRITORY

NATIONAL TIDAL CENTRE
BUREAU OF METEOROLOGY
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ABSTRACT

The historical tsunami record of the northern Australian region is reviewed. The propagation of tsunamis and their potential impacts along the north Australian coastline are investigated using a hydrodynamic tsunami model. Differences in tsunami characteristics are examined for three source regions; the Java Trench, the Timor Trough and the Banda Sea.

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1. HISTORICAL EARTHQUAKES

The seismicity of the region to the north and east of Northern Territory is summarised in Figure 1, which shows the location and depth (km) below the earth's surface of historical earthquakes listed on the Historical Tsunami Database from year 416 – 2000 (HTDB, 2000). Northern Territory lies in close proximity to the seismically active Indonesian Archipelago.

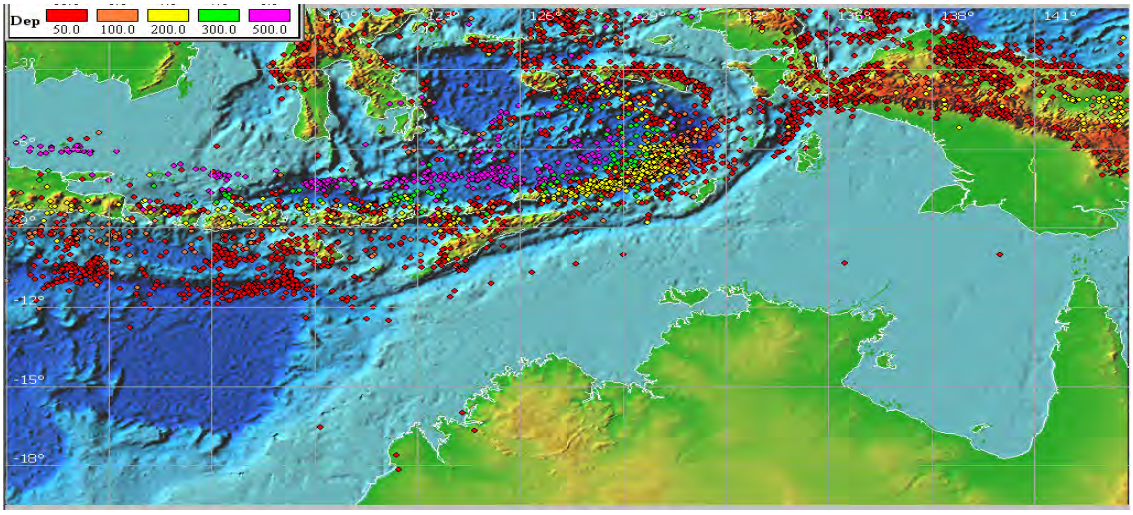


Figure 1. Map showing the epicentres and depth below the earth's surface of historical earthquakes in the region.

Only a small percentage of earthquakes that occur beneath the seafloor produce a tsunami. The Pacific Tsunami Warning Centre issues a preliminary tsunami warning for earthquakes within or near the Pacific Ocean basin if their magnitude exceeds 6.5. A tsunami will only be generated if there is significant vertical displacement of the seafloor. In some cases the ground shaking may induce a coastal or submarine tsunamigenic landslide. Tsunamigenic earthquakes typically occur at shallow depths below the surface. Figure 2 shows historical earthquakes of magnitude greater than 6.5 and depth less than 100 km.

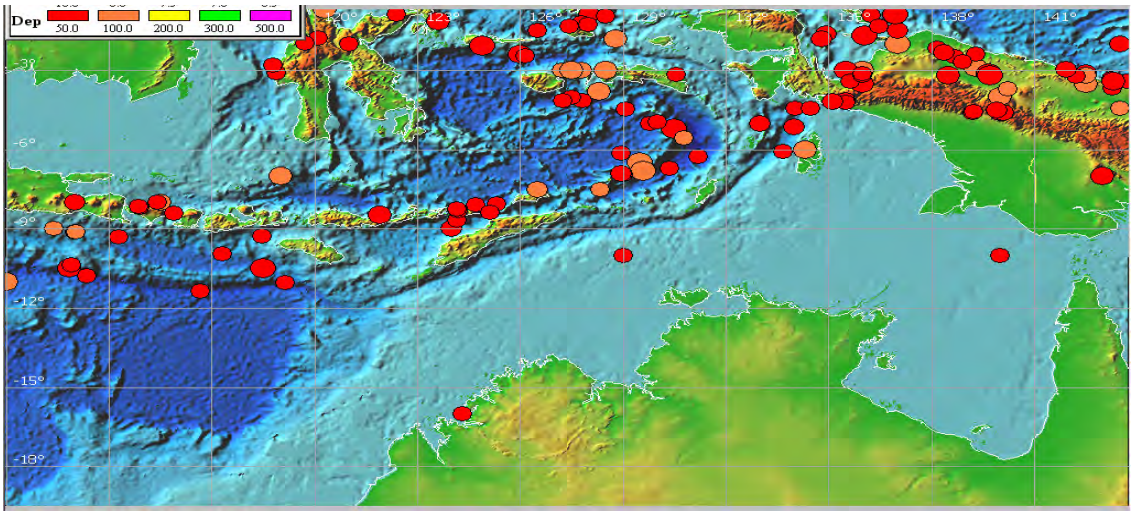


Figure 2. Subset of historical earthquakes that have magnitudes greater than 6.5 and depths less than 100km (HTDB, 2000), indicating only a small percentage of earthquakes are potentially tsunamigenic.

2. HISTORICAL TSUNAMIS

The sources of historical tsunamis (since 416 AD) in the region are shown in Figure 3 (HTDB, 2000), with the magnitude of the earthquake and intensity of the resultant tsunami depicted by the size and colour of the symbols. The intensity of the tsunami is not always proportional to the size of the earthquake. For example, an unusually large tsunami was generated after a modestly sized (Mw7.2) earthquake off the north coast of Papua New Guinea on July 17, 1998. The reason the tsunami was larger than expected was due to a submarine landslide triggered by the earthquake.

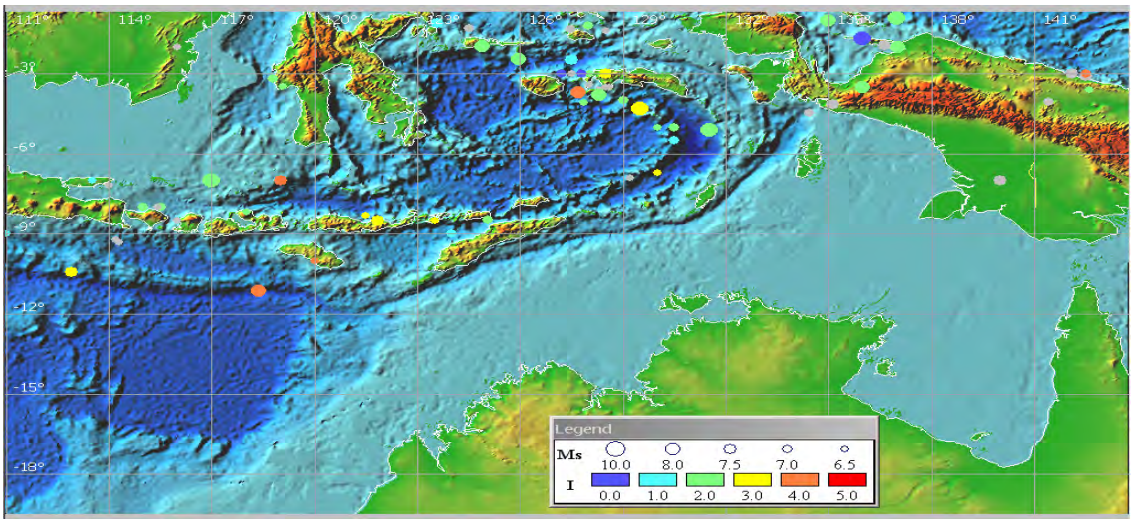


Figure 3. Map showing the source of historical tsunamis in the region including the earthquake size (Ms) and tsunami intensity (I) (HTDB, 2000).

The historical tsunami wave height reports for the region are shown in Figure 4 (HTDB, 2000). Reports of tsunamis along the Northern Territory coastline are rare. The wide continental shelf and islands to the north provide protection from tsunamis generated from earthquakes along the Java Trench and within the Indonesian Seas. Sea level effects due to tsunamis may also be small in comparison to the large tidal extremes found across much of northern Australia.

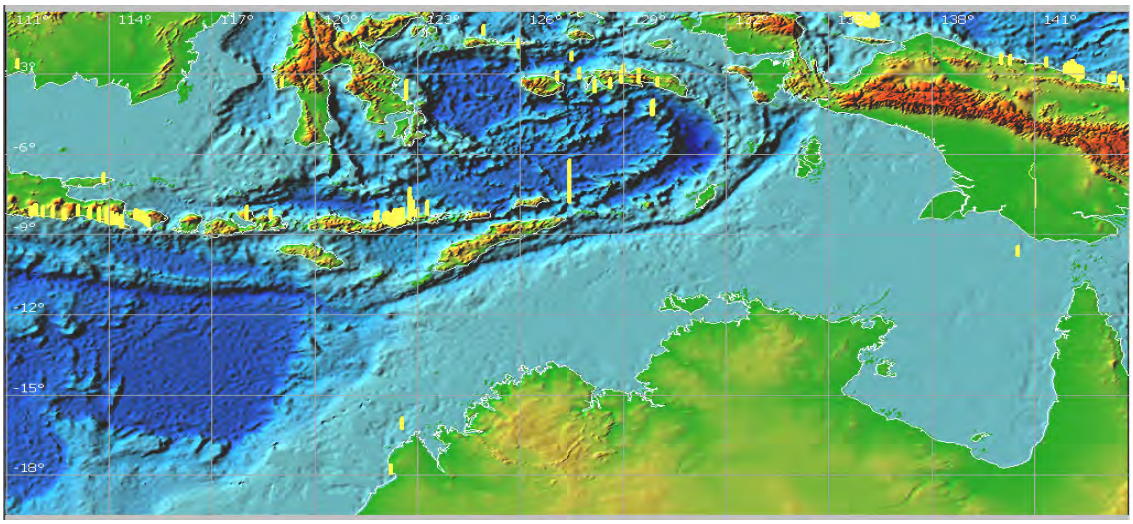


Figure 4. Map showing reported tsunami wave heights in the region as listed on the historical tsunami database (HTDB, 2000). The wave height at Cape Leveque is equivalent to 6m.

The following tsunamis are three examples listed on the historical tsunami database (HTDB, 2000; NGDC, 2005).

The 1852 Banda Sea Earthquake

An earthquake of magnitude Ms 8.2 occurred at 5.2S, 129.7E in the Banda Sea on November 26, 1852 and generated a destructive tsunami. The reported tsunami runup was 8m at Amboina, 3m at Saparua Island and 2m at Banda Neira. The number of deaths is listed as 60.

The 1938 Banda Sea Earthquake

On February 1, 1938 an earthquake of magnitude Mw 8.5 occurred at 5.05S, 131.62E in the Banda Sea, Indonesia and is listed as the 12th largest in the world since 1900 (USGS, 2005). A tsunami was generated which caused damage across the Banda, Kai and Tayandu Islands. The maximum tsunami runup was reported at 2m.

The 1977 Sumbawa Earthquake

On August 19, 1977, an undersea earthquake of magnitude Ms 8.0 occurred at 11.0S, 118.4E in the Java trench south of Sumbawa. The resulting tsunami caused much damage and 189 reported deaths. Tsunami runups exceeding 10m were reported on Sumbawa Island. A tsunami runup of 6m was reported at Cape Leveque, Western Australia, which is the largest ever reported in Australia. Other tsunami runup reports in Australia included 4m at Port Sampson and 2m at Dampier.

3. TSUNAMI MODELLING

Three tsunami scenarios are modelled due to earthquakes in the Java Trench, Timor Trough and Banda Sea (Figure 5). The source location of the Java Trench scenario is the same as the Ms8.0 earthquake of August 19, 1977. The source location of the Banda Sea earthquake scenario is the same as the Mw8.5 earthquake of February 1, 1938. To date there is no record of a tsunamigenic earthquake occurring along the Timor Trough.

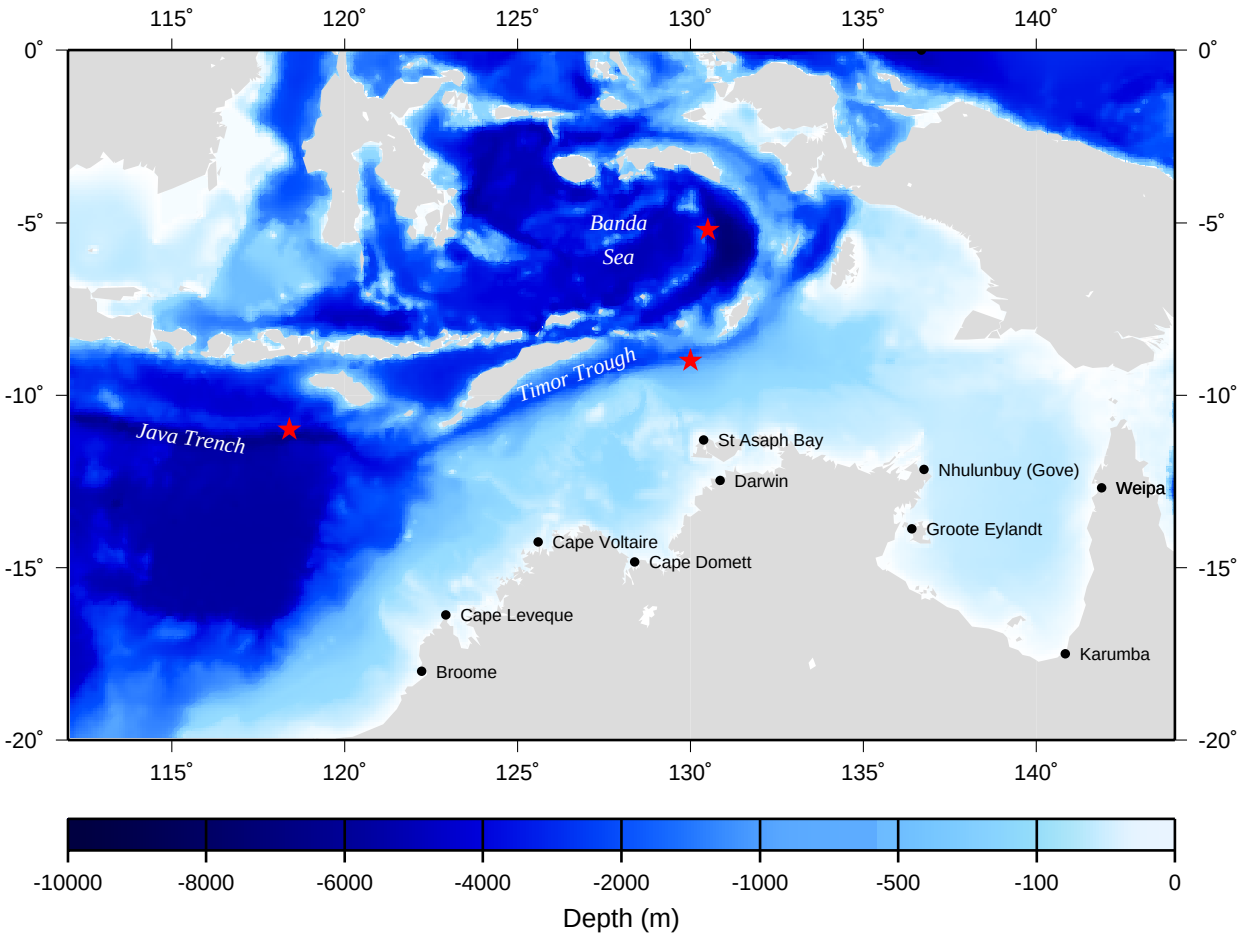


Figure 5. Map showing the epicentres (stars) of three earthquake scenarios used to investigate tsunami effects at locations along the Northern Territory coastline. The Banda Sea and Java Trench epicentres are in the same locations as tsunamigenic earthquakes that occurred in 1938 and 1977.

3.1 Seismic Parameters

The seismic parameters such as the fault length, width, depth, dip angle and amount of dislocation are held equal for each scenario. Only the location of the epicentre and the strike angle of the fault differ. The predicted tsunami effects along the northern Australian coastline are thereby an indication of different oceanographic exposure rather than different faulting mechanisms. In reality, the size and nature of the faulting mechanism is a very important part of the tsunami generation process, and the typical faulting mechanism in one region may differ from the next

The seismic parameters used for the three earthquake scenarios are shown in Table 1, and the resultant modelled seafloor displacements are shown in Figure 6.

Earthquake Scenario	Lat	Lon	Depth (km)	Length (km)	Width (km)	Strike	Dip	Slip	Dislocation (m)	Duration (secs)
Java Trench	-11.0	118.4	25	500	100	260	25	90	15	120
Timor Trough	-9.0	130.0	25	500	100	265	25	90	15	120
Banda Sea	-5.05	131.62	25	500	100	150	25	90	15	120

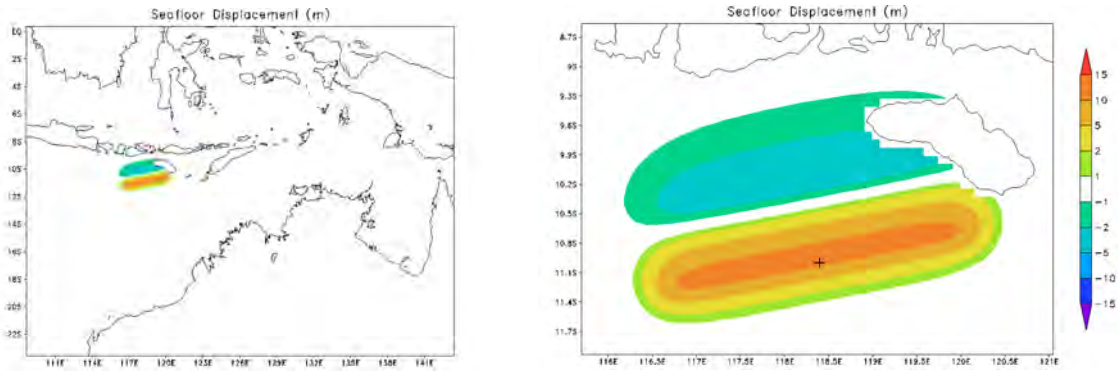
Table 1. Earthquake parameters used for the modelled tsunami scenarios.

3.2 Hydrodynamic Parameters

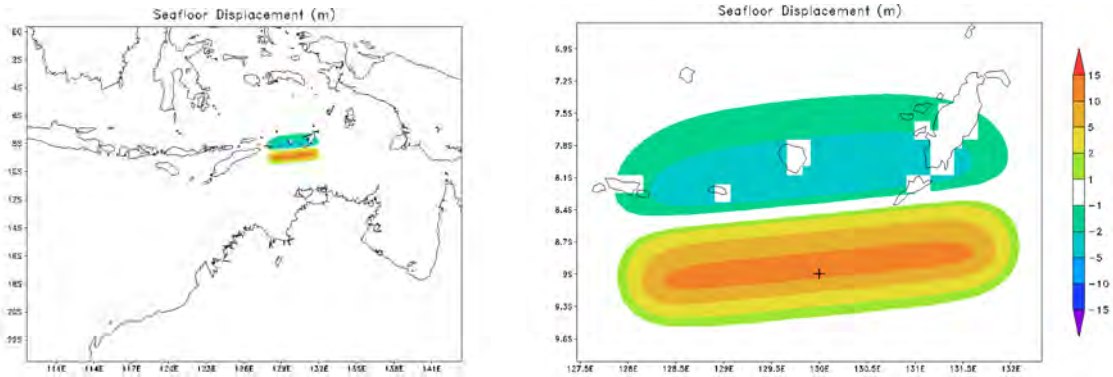
The numerical tsunami model ***tsunami1*** used at the National Tidal Centre (NTC) is a finite-difference, spherical polar coordinate version of the depth-integrated equations of motion that includes non-linear advection, coriolis, horizontal diffusion and quadratic bottom friction (Mitchell et al, 2001). The vertical seafloor displacement due to the earthquake is solved analytically (Okada, 1985) and ramped in time over a rupture duration in order to generate the tsunami. A radiation condition allows tsunami waves to transmit through the open ocean boundary.

The hydrodynamic parameters used for each tsunami simulation include a gridsize of 5 minutes in both latitude and longitude, a timestep of 10 seconds and a run time of 48 hours. The coefficients of bottom friction and reduced eddy viscosity used were 0.0035 and 0.0005. The model bathymetry was derived from a NTC 5-minute dataset. The modelled sea level results were saved at time intervals of 2 minutes.

Java Trench Scenario



Timor Trough Scenario



Banda Sea Scenario

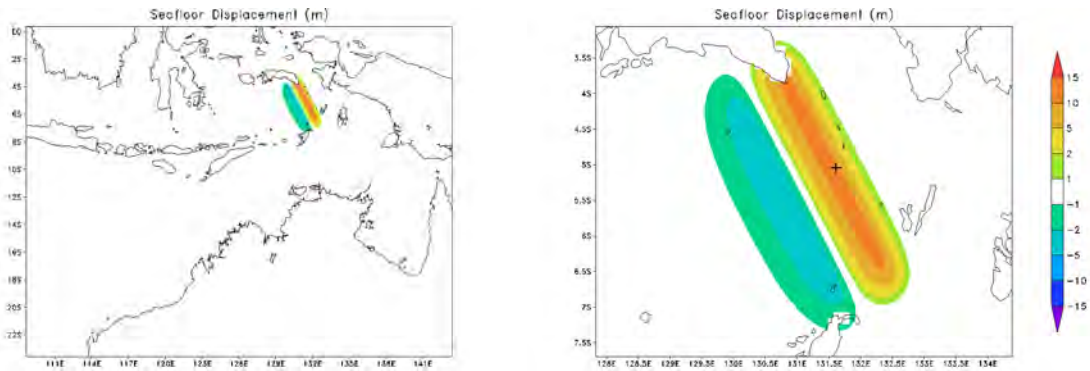


Figure 6. Modelled vertical seafloor displacements (m) for the three earthquake scenarios.

3.3 Model Results

Charts of modelled tsunami range and tsunami travel time as well as timeseries plots at selected coastal locations along the northern Australian coastline (Figure 5) are presented for the tsunamis generated in the Java Trench (Figures 8-10), Timor Trough (Figures 11-13) and Banda Sea (Figures 14-16).

For the Java Trench scenario a modelled tsunami peak of 5m at Cape Leveque (Figure 10) is comparable to the reported tsunami runup of 6 m after the August 19, 1977 Ms 8.0 earthquake.

The 1938 Banda Sea Mw 8.5 earthquake was not particularly tsunamigenic given the size of the earthquake. Tsunami runups up to 2 m were reported across islands in the epicentral area. In this study the earthquake rupture size is kept constant for each source region, which results in a larger tsunami than that observed after the 1938 earthquake. Larger tsunamis have been observed in the Banda Sea however, such as in 1852 when the maximum reported tsunami runup was 8m.

A comparison of the tsunami characteristics at selected locations along the north Australian coastline for each scenario is shown in Figure 7. The largest modelled tsunami, given the same amount of seafloor displacement, is produced from the Java Trench although its significance is confined mostly to the Western Australian coastline. Larger modelled tsunamis were found along the Northern Territory coastline when the source region was the Timor Trough, and to a lesser extent the Banda Sea. All three scenarios show diminishment of tsunamis propagating into the Gulf of Carpentaria. Tsunamis are more prominent at locations closer to the edge of the shelf, such as Cape Voltaire, St Asaph Bay and Cape Leveque. The wide and shallow continental shelf causes frictional dissipation of tsunamis.

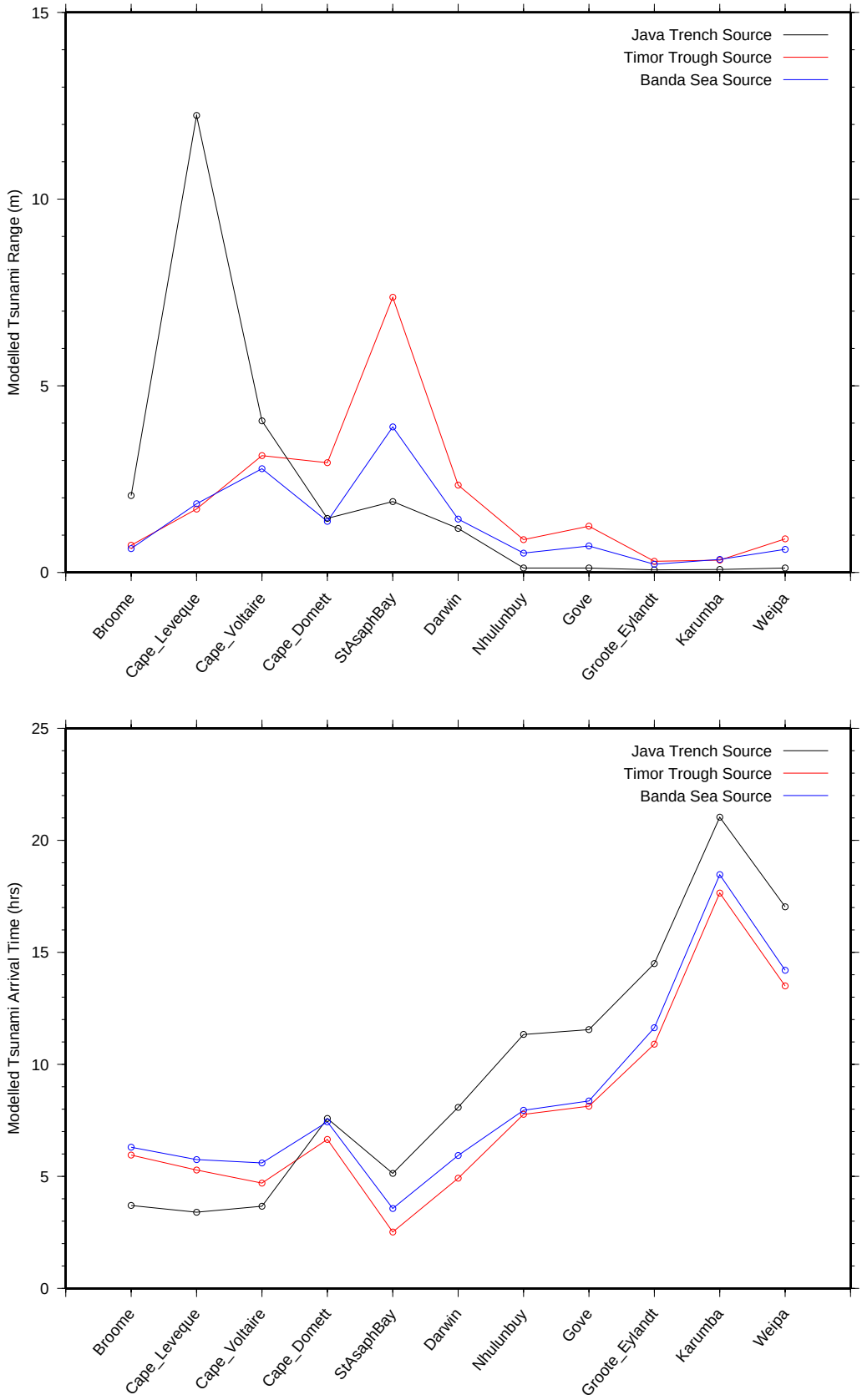


Figure 7. Modelled tsunami range (m) and arrival time (hrs) at selected coastal locations along the northern Australian coastline for the three tsunami sources.

Java Trench Scenario

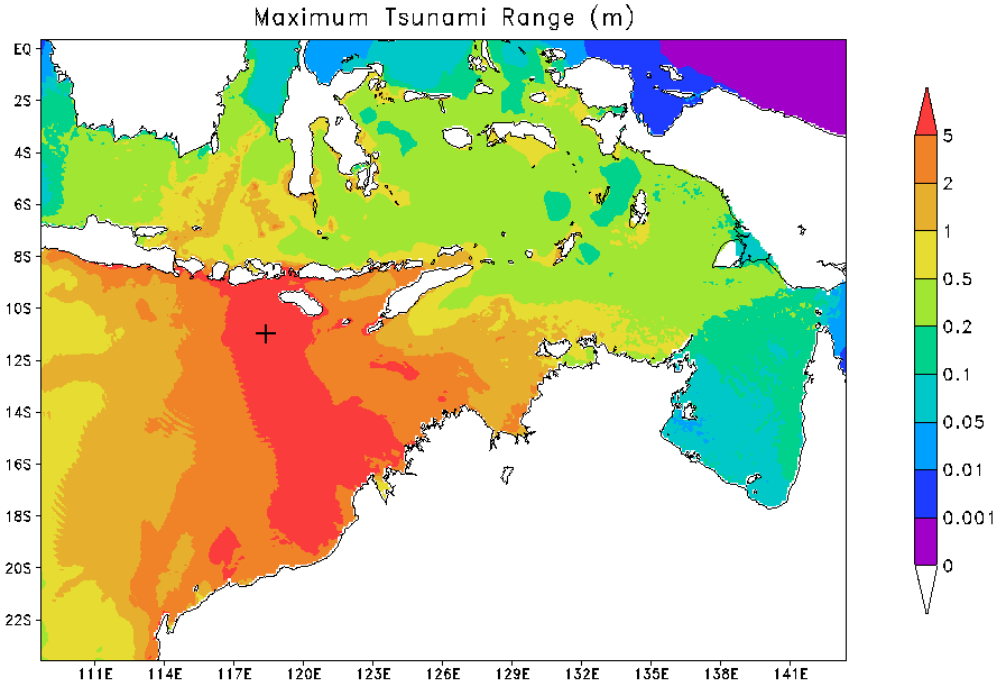


Figure 8. Modelled tsunami range (m) for the Java Trench scenario.

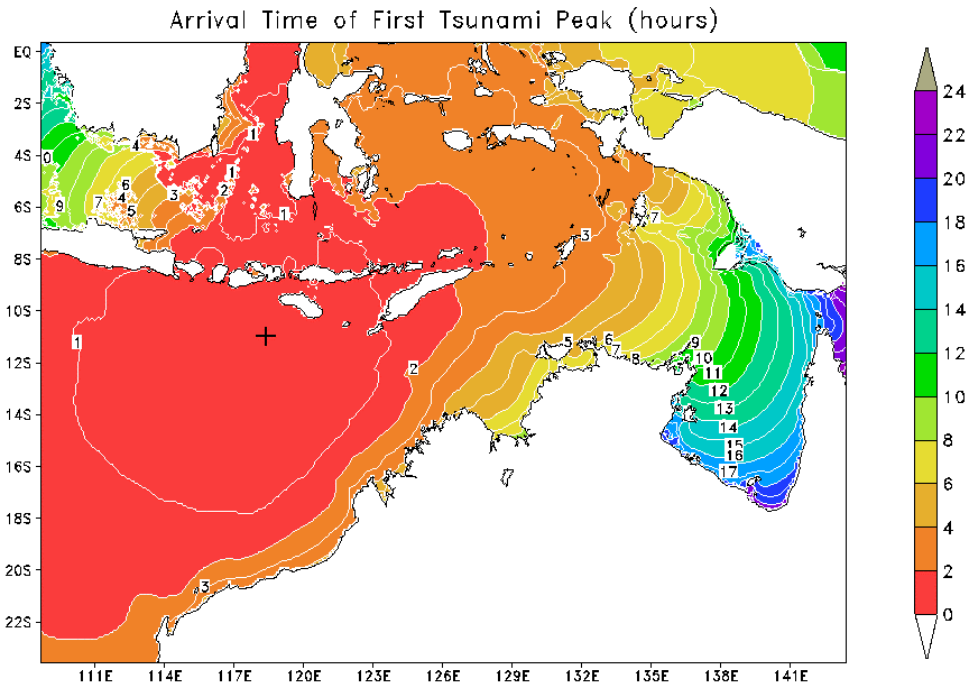


Figure 9. Modelled tsunami travel time (hours) for the Java Trench scenario.

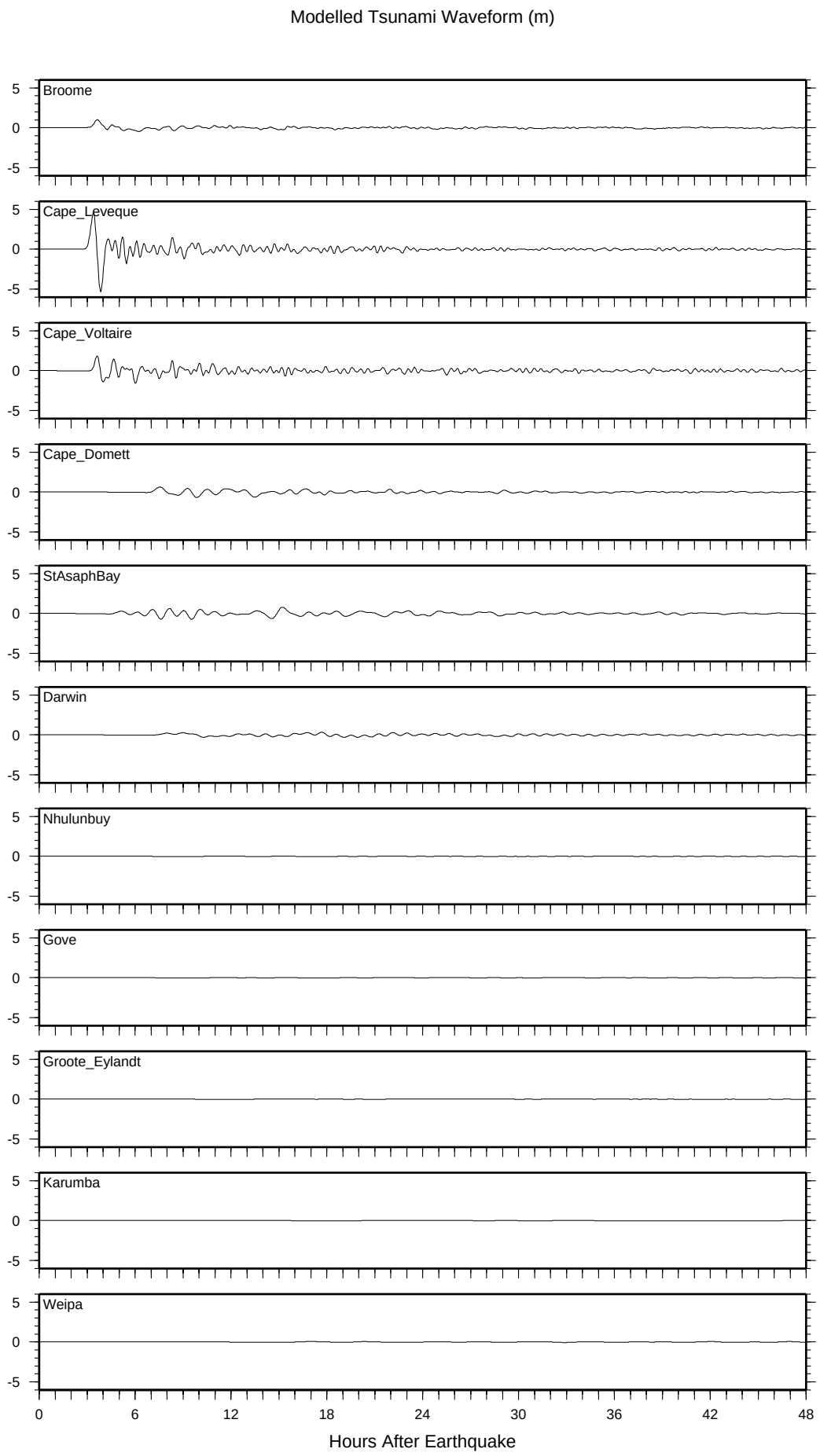


Figure 10. Modelled tsunami waveform (m) at certain locations for the Java Trench scenario.

Timor Trough Scenario

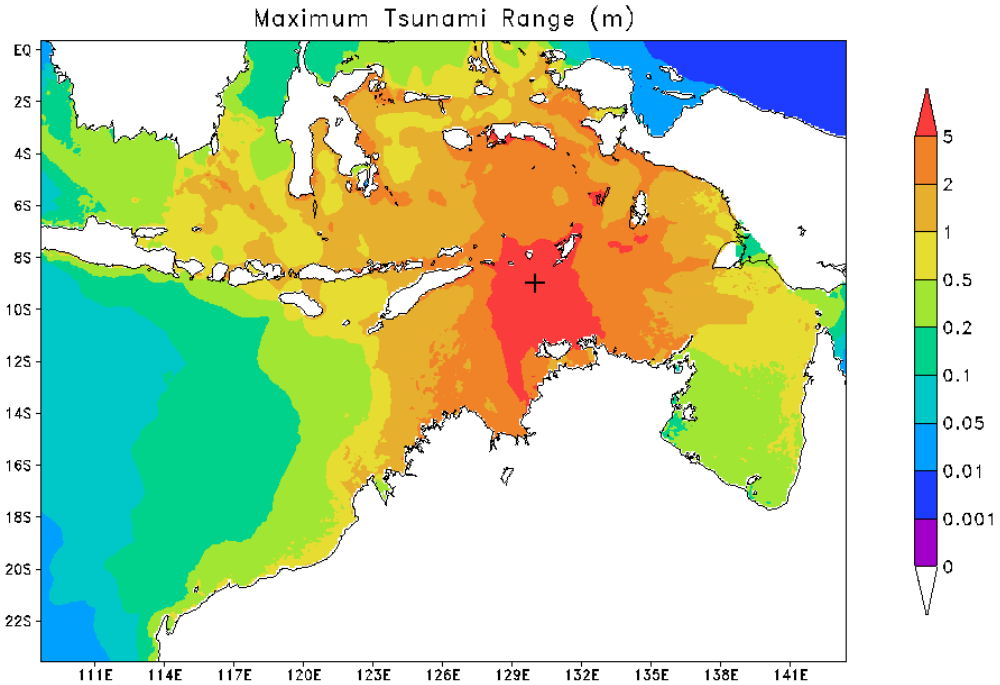


Figure 11. Modelled tsunami range (m) for the Timor Trough scenario.

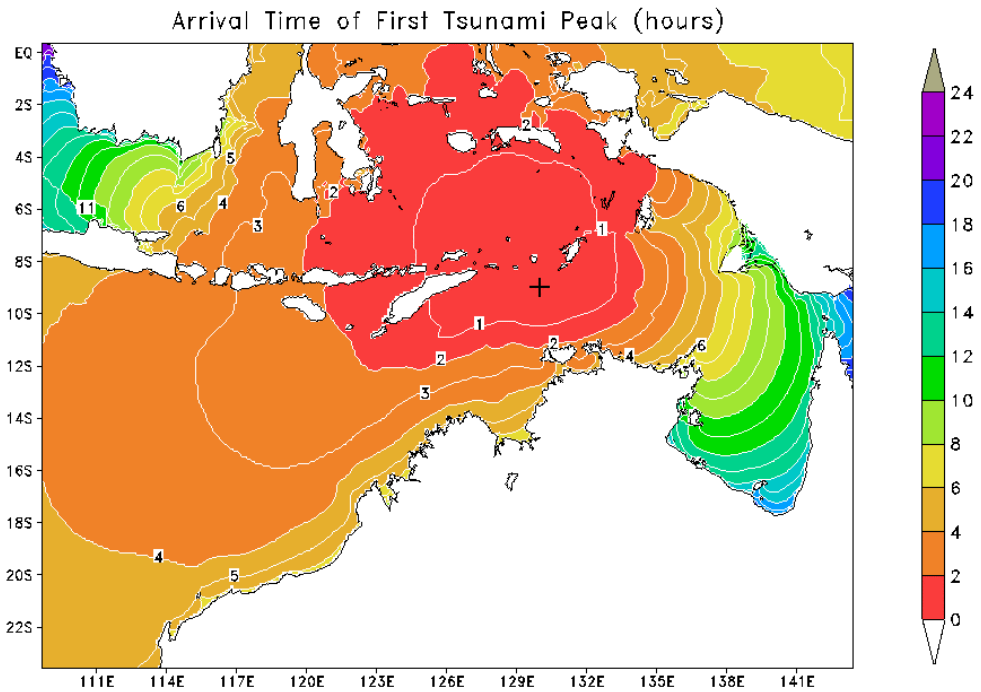


Figure 12. Modelled tsunami travel time (hours) for the Timor Trough scenario.

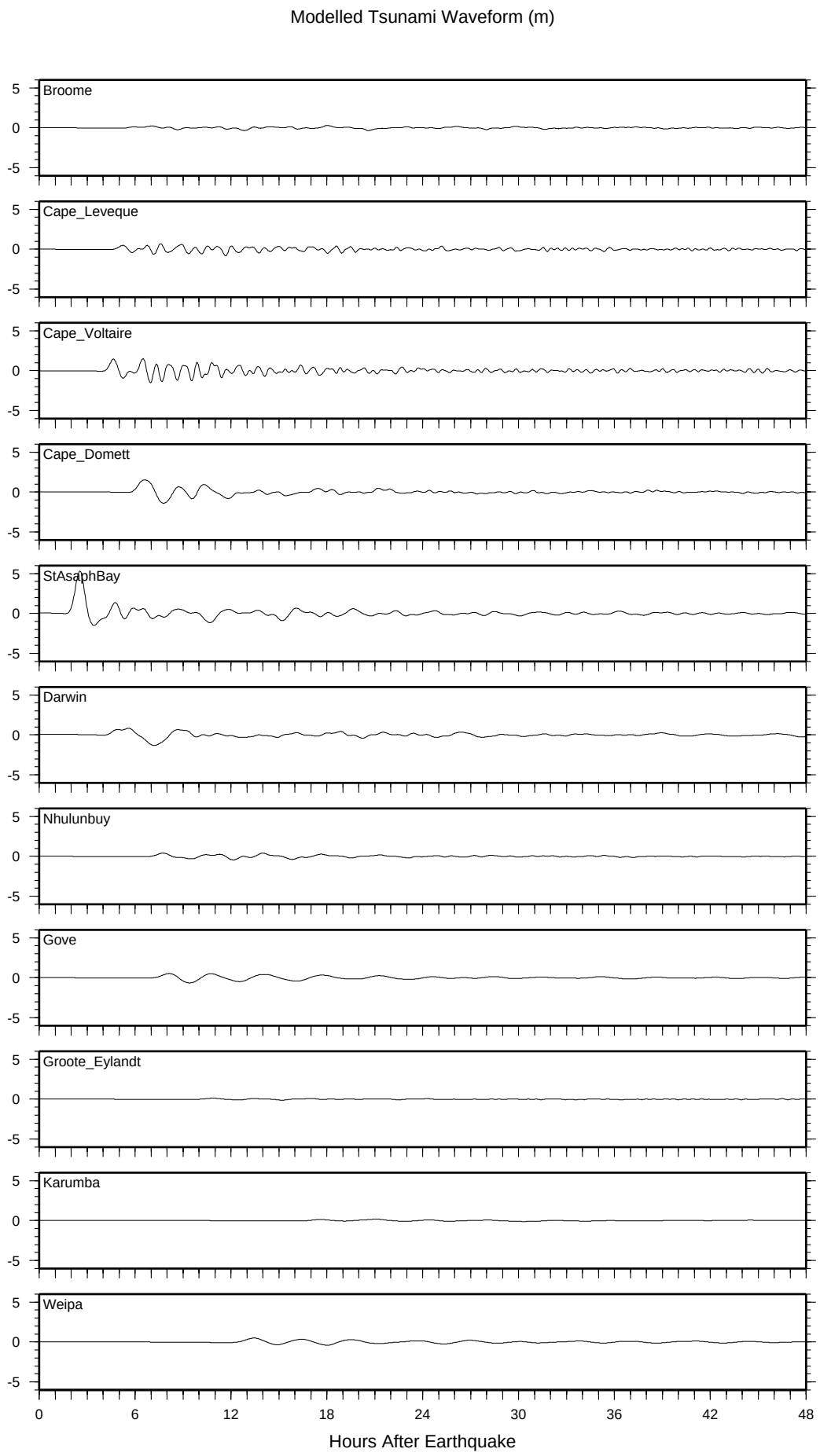


Figure 13. Modelled tsunami waveform (m) at certain locations for the Timor Trough scenario.

Banda Sea Scenario

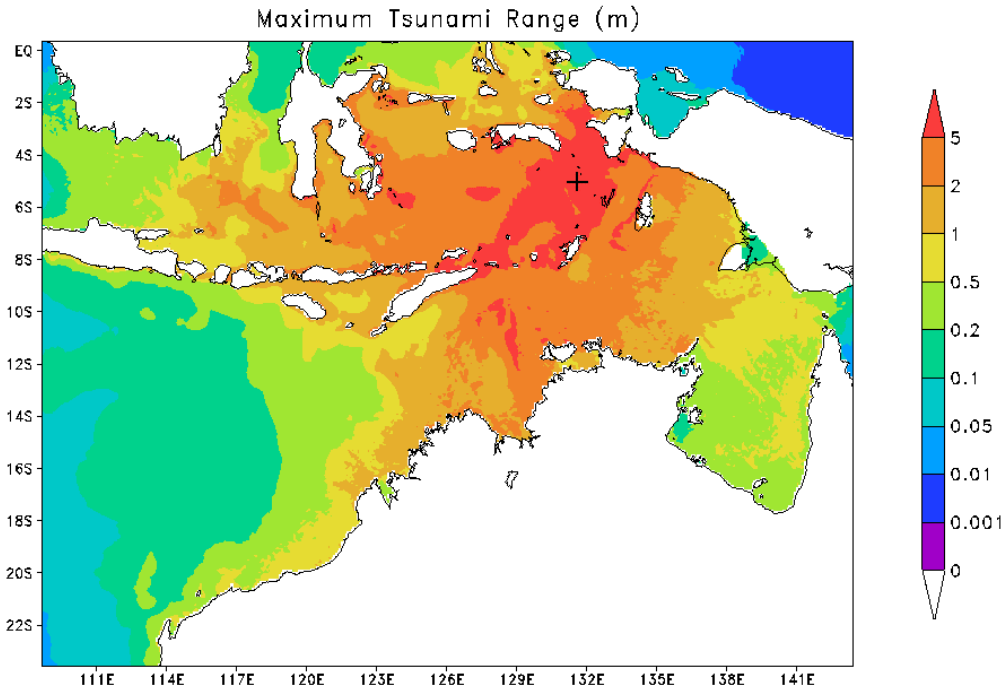


Figure 14. Modelled tsunami range (m) for the Banda Sea scenario.

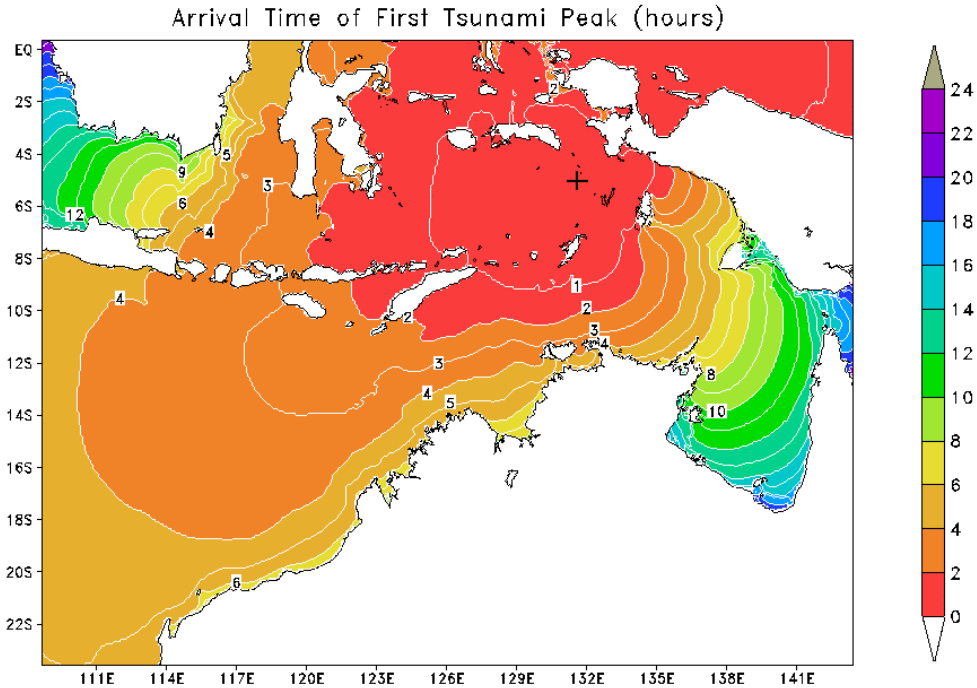


Figure 15. Modelled tsunami travel time (hours) for the Banda Sea scenario.

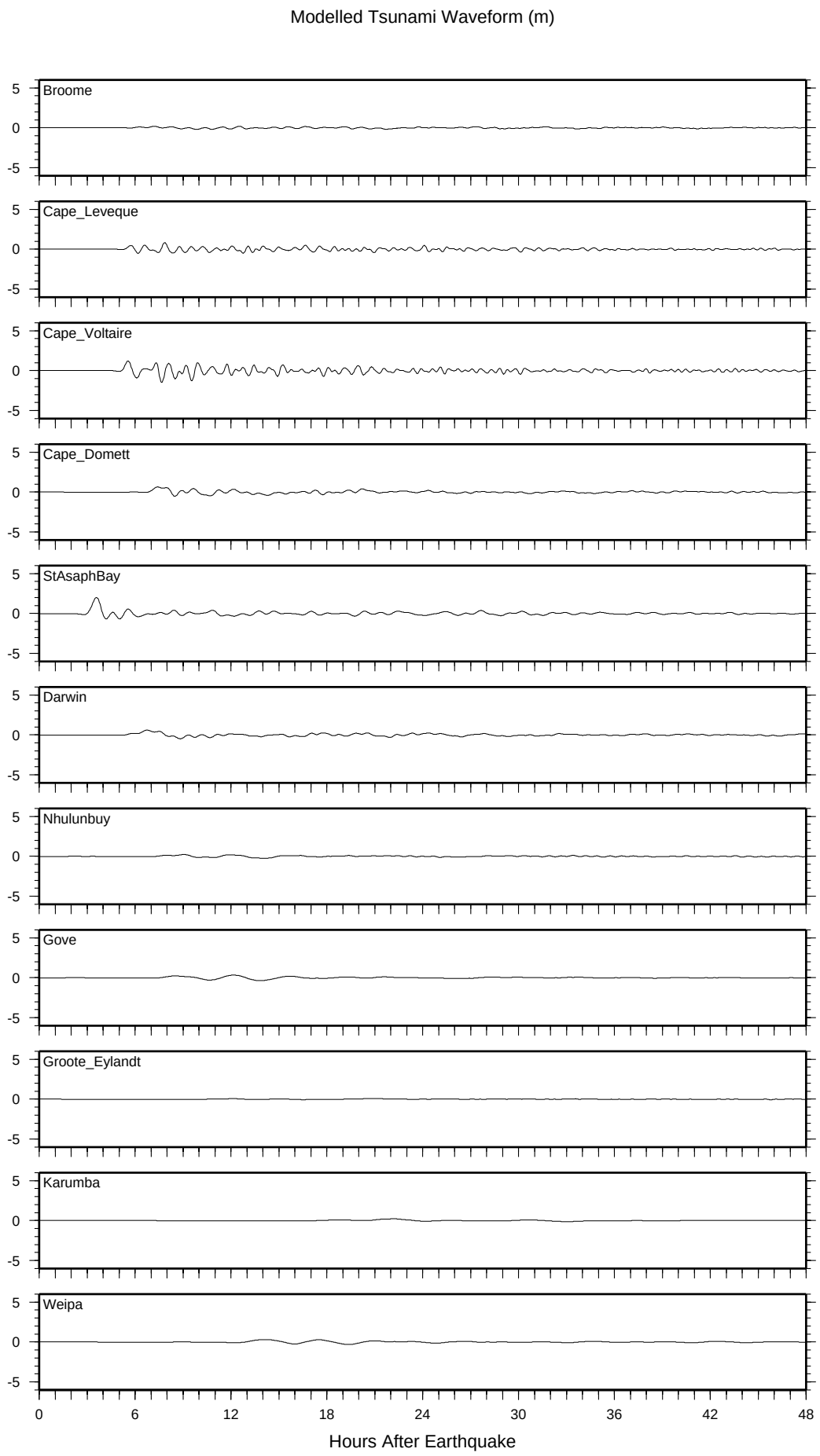


Figure 16. Modelled tsunami waveform (m) at certain locations for the Banda Sea scenario.

4. CONCLUSION

Historically, tsunamis are rare along the Northern Territory coastline. The largest tsunamis are generated in the Java Trench, but their effects are small by the time they reach the Northern Territory coastline due to dissipation over the continental shelf. A potentially larger risk for Northern Territory is posed by tsunamis generated to the north, such as in the Timor Trough or Banda Sea. However, the seismicity of the Timor Trough is comparatively inactive, while the historical record shows tsunamigenic earthquakes within the Banda Sea typically do not produce tsunamis large enough to be observed along the Australian coastline.

Modelling tsunamis from three different source regions has provided information such as coastal regions most at risk from tsunamis, tsunami travel times or propagation speed, and comparisons of tsunami characteristics at certain locations along the north Australian coastline.

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