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Digital elevation models in the marine domain: investigating the offshore tsunami hazard from submarine landslides

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Over the past 30 years multibeam bathymetry has replaced single-beam echo soundings as the main tool used to map the sea floor. Developed as a military tool its expansion into the scientific domain has revolutionized our ability not only to visualise seabed morphology, but also to interpret the active processes taking place at and beneath the seabed. DEMs derived from multibeam are now comparable to those on land.

One aspect of the improved seabed visualization is in mapping marine geohazards, in this instance, submarine landslides. One of the first multibeam surveys actually programmed to investigate an actual event was in 1999 after the tsunami on the north coast of Papua New Guinea killed 2,200 people. It was a wake-up call, as the relatively small magnitude earthquake – 7.1 – could not generate tsunami waves up to 15m high at the coast. The submarine slump was clearly visible on the multibeam and associated seabed sampling confirmed that it was a recent event. Subsequent research proved that the landslide generated the tsunami as, again for the first time the multibeam was used as the basis for the tsunami simulations.

Since 1999 many submarine landslides have been mapped, but not all have an associated identified tsunami. Some landslides are associated with earthquakes and this causes confusion if there is an anomalously large tsunami for example Alaska, 1946 and Java, 2006. Others are suspected of causing a tsunami, but their evidence on the seabed is hard to identify as with Messina, 1908. The most confusing recent tsunami event has been 2011 Japan tsunami, where a submarine landslide to the north of the main rupture is almost certainly responsible for the 40m high coastal waves that struck northern Honshu.

The seabed has now been mapped on a broadscale by satellite gravity, but maps from this method cannot identify any but the largest seabed morphologies; most submarine landslides cannot therefore be recognised. Large seabed areas still remain unmapped to the resolution necessary to identify the hazard from landslides, particularly along convergent margins where this hazard is the greatest.

Multibeam mapping of the deep seabed requires low frequency sound sources that, because of their corresponding low resolution, cannot produce the detail required to identify the finest scale features. In addition, outside of most countries, there are not the repeat surveys that allow seabed changes to be identified. Perhaps only japan has this data. In the near future as research budgets shrink and ship time becomes ever expensive new strategies will have to be used to make best use of the vessels available. Remote AUV technology is almost certainly the answer, and should be increasingly utilised to map the seabed while the mother ship is better used to carry out other duties, such as sampling or seismic data acquisition. This will have the advantage in the deep ocean of acquiring higher resolution data from high frequency multibeams.

This talk presents on a number of projects that show the evolution of the use of MBES in mapping submarine landslides since the PNG tsunami. Data from PNG is presented, together with data from Japan, Hawaii and the NE Atlantic. New multibeam acquisition methodologies are also discussed.