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Research News

Evolution of DART technology and development of fourth generation bouy system for deep ocean assessment and reporting of tsunami - (DART 4G)

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Introduction

Deep-ocean tsunami detection buoys are used to confirm the existence of tsunami waves generated by undersea earthquakes. These buoys observe and record changes in sea level out in the deep ocean. This enhances the capability for early detection and real-time reporting of tsunamis before they reach land.

The DART stands for Deep Ocean Assessment and Reporting of Tsunamis. Deep-ocean tsunami detection buoy technology was initially developed in the United States of America by the Pacific Marine Environmental Laboratory (PMEL) of the National Oceanic and Atmospheric Administration (NOAA) as "DART™" (Deep-ocean Assessment and Reporting of Tsunami) buoys. A DART® system consists of a seafloor bottom pressure recording (BPR) system capable of detecting tsunamis and a moored surface buoy for real-time communications. An acoustic link is used to transmit data from the BPR on the seafloor to the surface buoy.

The development of first generation prototype started in 1995 and in August 2000, four DART systems were deployed and reporting data. This first generation was composed of two separate parts; a (Bottom Pressure Recorder) BPR and a separately moored surface buoy. The system was capable only of one-way communication and transmitted four sea level measurements per hour.

Second generation technology was developed in 2004 and the design incorporated two -way communication between the BPR and NOAA Tsunami Warning Centers, WHICH ENABLES Tsunami data transmission on demand. This capability ensures the measurement and reporting of tsunamis with amplitude below the auto-reporting threshold.(Christian Meinig et al. 4th June 20015 Real-Time Deep-Ocean Tsunami Measuring, Monitoring, and Reporting System: The NOAA DART II Description and Disclosure)

The 3rd Generation was developed by PMEL,NOAA in 2007 to integrate the BPR and surface buoy into one easy to deploy (ETD) system-DART-ETD. The ETD DART® is designed to be deployed by small and fast response vessels, requires fewer trained personnel, and takes only minutes of deployment time. (RA Lawson et al ,2012,The next generation Easy-to-Deploy (ETD) tsunami assessment buoy). DART-ETD offers the same two-way communication as DART II and the first commercial deployment started in 2010.

Computation of tsunami models in the region adjacent to large earthquakes immediately after rupture initiation remains a challenging problem. Limitations of traditional seismological instrumentation in the near field and concern by tsunami modelers regarding the nonuniqueness of source inversions and the use of indirect observations have in the past been hurdles for such efforts, justifying the need to provide enough information to issue timely and accurate forecasts of tsunami intensity immediately or shortly after rupture initiation of large earthquakes. (Diego Melgar et al ,22nd Nov 2013 Journal of Geophysical Research, Near-field tsunami models with rapid earthquake source inversions from land- and ocean-based observations: The potential for forecast and warning)

A long-time goal of tsunami assessment has been to develop a sensor that can detect and measure near-field tsunamis as close to the generation area as possible, as this will provide any country much faster access to data, which could improve evacuation time.

NOAA PMEL developed a fourth-generation (4G) DART system having the potential to solve the near-field data collection challenge. 4th Generation DART buoys, or 4G, began development in 2013 for the measurement of near-field tsunamis.

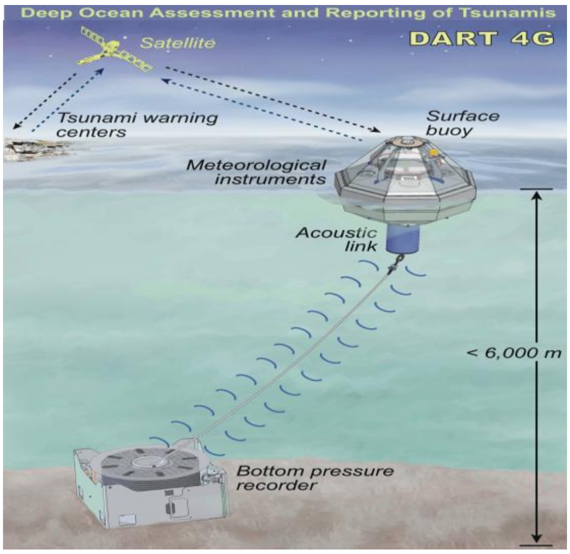

Fig 1- A schematic representation of a 4th Generation deep-ocean tsunami

The following are distinctive features of DART 4G Bouy Systems

• Advanced pressure sensor and software;
• Tsunami measured closer to the earthquake source
• Higher resolution tsunami height data transmitted while the earthquake is rupturing;
• Allows the separation of the tsunami signal from the earthquake "noise."

System Description

- New DART 4G (4th generation) offers new detection and forecast capabilities designed for coastlines. The DART 4G is an enhanced version of the DART-ETD that incorporates advancement of sensors, software and power management to detect and measure near-field tsunami with unprecedented resolution. The improved pressure sensor is able to detect and measure a tsunami closer to the earthquake source providing valuable information to warning centers even faster and allowing the moorings to be placed closer to earthquake zones (and consequently the coastline). (Ref:https://pmel.noaa.gov/news-tory/pmel-deploys-latest-tsunami-detection-system)

- The 4G DART system consists of an anchored seafloor bottom pressure recorder (BPR) and a companion moored surface buoy for real time communications.

- BPR(Bottom Pressure Recorder) detects and measures tsunamis with amplitudes as small as 1 mm in 6,000 m of water.

Fig 2- The deployment of a DART™ buoy detection buoy (DART™).

- *Surface Buoy*
  Serves as the communication link between the BPR and Tsunami Warning Center staff. An acoustic modem transmits data from the BPR on the seafloor at regular intervals to the surface buoy, which then relays the information to a ground station via satellite telecommunications.

When a tsunami is detected, the BPR sends data to the surface buoy more often. All data sent to the surface buoy are relayed to a ground station via satellite. Two test DART 4G systems are currently deployed off the coast of Oregon with the technology currently being transferred to commercial partner of NOAA, the Science Applications International Corp. (SAIC).

Conclusion

Due to the complexity and uncertainty as to whether an undersea earthquake has the potential to generate a tsunami, the observation of sea levels is a critical factor in verifying whether a tsunami has actually been generated.

The use of actual sea level observations, as compared with reliance on seismic observations alone, therefore helps to significantly reduce the risk of false tsunami warnings being issued. Short warning times and uncertainties related to tsunami hazard and early warning represent a big challenge to the scientific community in their effort to improve tsunami preparedness and implement strategies for tsunami early warning system. Recognizing these parameters and taking them into account should be the basis to develop a realistic preparedness strategy and an advanced warning system which should have the potential to detect and measure near filed Tsunamis close to the earthquake source.

Acknowledgements

The views expressed in the article are solely the views of myself and not my organisation and my employing organisation has no financial liability in the matter.

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