TSUNAMI MONITORING SYSTEM USING GPS BUOY – PRESENT STATUS AND OUTLOOK –

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One of the most effective countermeasures against tsunami disaster is to detect tsunami before its arrival to the coast and to give warning to the coastal residents. A number of offshore tsunami monitoring systems were developed, among which ocean bottom pressure sensors have been widely used for this purpose. We have developed a new tsunami monitoring system using a GPS buoy for over 12 years (Kato et al., 2000; Figure 1). Real-time kinematic (RTK) GPS technology was used for this purpose. GPS buoy is much easier to handle and maintain compared with ocean bottom sensors, though its sensitivity is a little inferior relative to the latter.

After a series of preliminary experimental studies, an operation-oriented experiment was conducted offshore Ofunato city, northern Tohoku, Japan, from 2001 to 2003. GPS antenna was set at the top of a buoy and 1-sec sampling data were transmitted to the ground base of about 1.6km distance together with other ancillary data. The data was processed at the ground base in near real-time and the estimated 3D positions were disseminated through internet. This system succeeded to detect two tsunamis of about 10cm in vertical amplitude by employing a simple filtering technique: 23 June 2001 Peru earthquake (Mw8.4) and 26 September 2003 Tokachi earthquake (Mw8.3). After this successful experiment, a newly designed system was established about 12km south of Cape Muroto, southwestern Japan in early April 2004 (Figure 2). The buoy has experienced nearby passages of several typhoons with a maximum wave of about 20 meter in height and has shown a total integrity for an operational use. On September 5th 2004, a large earthquake of Mw7.4 occurred about 200km east of the buoy. The GPS buoy successfully recorded the tsunami with about 10cm of vertical amplitude at the first peak arrival of about 10 minutes before its arrival at the nearest coast of Muroto Promontory (Kato et al., 2005). Kato et al. (2005) indicated that the simulated record has shown excellent consistency with the observed tsunami, suggesting high potential for predicting tsunami height at the coast before its arrival, if the record is efficiently implemented in the tsunami warning system.

The developed GPS buoy system has been adopted as a part of the Nationwide Ocean Wave information system for Port and HArborS (NOWPHAS) by the Ministry of Land, Infrastructure, Transport and Tourism. They have established more than eight GPS buoys along the Japanese coasts and the system has been operated by the Port and Airport Research Institute.

As a future scope, we are now planning to implement some other additional facilities for the GPS buoy system. The first application is a so-called GPS/Acoustic system for monitoring ocean bottom crustal deformation. The system requires acoustic waves to detect ocean bottom reference position, which is the geometrical center of an array of transponders, by measuring distances between a position at the sea surface (vessel) and ocean bottom equipments to return the received sonic wave. The position of the vessel is measured using GPS. The system was first proposed by a research group at the Scripps Institution of Oceanography in early 1980's (Spiess, 1985). The system was extensively developed by Japanese researchers and is now capable of detecting ocean bottom positions with a few centimeters in accuracy (Fujita et al., 2006). The system is now operational for more than ten sites along the Japanese coasts. Currently, however, the measurements are not continuous but have been done once to several times a year using a boat. If a GPS and acoustic system is placed on a buoy, ocean bottom position could be monitored in near real-time and continuous manner. This will allow us to monitor more detailed and short term crustal displacements.

The second plan is for an atmospheric research. Rocken et al. (2005) and Fujita et al. (2008) showed that GPS is capable of measuring atmospheric water vapor through tropospheric zenith delay measurements. Information of water vapor content and its temporal variation over sea surface will much contribute to weather forecast on land which has mostly been conducted only by land observations. Considering that the atmospheric mass moves from west to east in general in and around Japanese islands, information of water vapor together with other atmospheric data from an array of GPS buoy placed in the west of Japanese Islands, will much improve weather forecast. We try to examine if this is also feasible.

As a conclusion of a series of GPS buoy experiments, we could assert that GPS buoy would be a powerful tool to monitor ocean surface and much contribute to provide safe and secure life of people.

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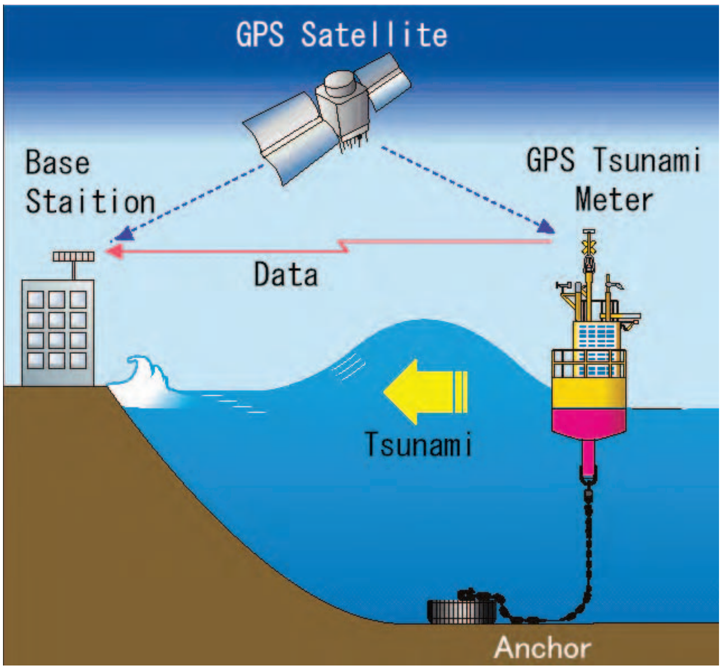

Figure 1: Concept of a GPS buoy.

Figure 2: GPS buoy installed offshore of Cape Muroto, Japan