Geophysical Research Abstracts
Vol. 16, EGU2014-15396, 2014
EGU General Assembly 2014

GeoSEA: Geodetic Earthquake Observatory on the Seafloor

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Space geodetic observations of crustal deformation have contributed greatly to our understanding of plate tectonic processes in general, and plate subduction in particular. Measurements of interseismic strain have documented the active accumulation of strain, and subsequent strain release during earthquakes. However, techniques such as GPS cannot be applied below the water surface because the electromagnetic energy is strongly attenuated in the water column. Evidence suggests that much of the elastic strain build up and release (and particularly that responsible for both tsunami generation and giant earthquakes) occurs offshore. To quantify strain accumulation and assess the resultant hazard potential we urgently need systems to resolve seafloor crustal deformation.

Here we report on first results of sea trials of a newly implemented seafloor geodesy array. The GeoSEA (Geodetic Earthquake Observatory on the Seafloor) array consists of a seafloor transponder network comprising 35 units and a wave glider acting as a surface unit (GeoSURF) to ensure satellite correspondence, data transfer and monitor system health. Seafloor displacement occurs in the horizontal (x,y) and vertical direction (z). The vertical displacement is measured by monitoring pressure variations at the seafloor. Horizontal seafloor displacement can be measured either using an acoustic/GPS combination to provide absolute positioning (requiring a suitably equipped vessel to perform repeated cruises to provide the GPS fixes) or by long-term acoustic telemetry between different beacons fixed on the seafloor to determine relative distances by using the travel time observations to each other, which is the technique tested during our short sea trials. For horizontal direct path measurements, the system utilizes acoustic ranging techniques with a ranging precision better than 15 mm and long term stability over 2 km distances. Vertical motion is obtained from pressure gauges. Integrated inclinometers monitor station settlement in two horizontal directions. Data can be acquired and recorded autonomously subsea without system or human intervention for up to 6 years. These data can then be recovered via the integrated high-speed acoustic telemetry link without recovering the seafloor units. When requested to do so, the stored data will be transmitted wirelessly up to the sea surface to the GeoSURF wave glider for onward transmission via a satellite link. Targets for GeoSEA are the marine sector of the North Anatolian fault zone in the Marmara Sea, where a joint French-German array will be installed in late 2014 as well as the central sector of the South America – Nazca convergent plate boundary along the Iquique segment, offshore Northern Chile. Here, the GeoSEA array will be installed in late 2015 to monitor crustal deformation. Mobile autonomous seafloor arrays for continuous measurement of active seafloor deformation in hazard zones have the potential to lead to transformative discoveries of plate boundary/fault zone tectonic processes and address a novel element of marine geophysical research.