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An autonomously deployed, deep-ocean, broadband seismic network

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The establishment of approximately 20 high quality, broadband, permanent ocean seismic stations has long been envisioned to provide coverage in areas lacking nearby island or continental sites. In the IRIS grand challenges report (Seismological Grand Challenges in Understanding the Earth's Dynamic Systems) the need to extend seismological observations to the seafloor was clearly articulated. Of the 10 "Grand Challenges" identified, seven explicitly called for such seafloor stations to address the scientific problems. As examples, such improved spatial sampling would provide much-improved tomographic imaging of the structure of the lower mantle (especially in the Southern Hemisphere), the core-mantle boundary, and the role of subducting slabs and plumes in deep mantle circulation. Studies of regional structure and tectonics of many areas also require observations from oceanic areas. The lack of good coverage in oceanic areas seriously degrades the accuracy of determination of earthquake parameters such as location and moment and this is particularly critical for tsunami warning systems. Earthquakes in South America, for example, are often tsunamigenic, but are recorded primarily in the northern hemisphere, providing limited constraints on their source mechanism and rupture directivity. Moreover, since the seafloor deforms under the loading of surface gravity waves, a broadband seafloor seismic sensor combined with a traditional bottom pressure sensor will respond to a tsunami traveling overhead and contribute useful real-time data to a tsunami warning system.

Yet for all the years of planning, pilot experiments, and attempts to add a global seismology component to the NSF Oceans Observatory Initiative program (OOI), there are today no ocean bottom stations in the Global Seismic Network. The primary reason for this is simply the cost of deployment and maintenance of the current generation technology.

We are developing an autonomously deployed, deep-ocean seismic system (ADDOSS) to provide long-term and near-real-time seismographic observations from the deep oceans. We are combining two proven technologies to develop a new generation instrument, which will provide a means of increasing global coverage not only to seismic observations, but also to a variety of ocean bottom observables in an affordable and sustainable way.

In this effort, Scripps is teaming with a small company, Liquid Robotics, which has developed a new, breakthrough technology in deep ocean observations and telemetry. The Liquid Robotics Wave Glider technology comprises a surfboard-sized surface float tethered to a submerged glider, which converts wave motion into thrust and thereby tows the surface float. The surface float is equipped with solar panels, an Iridium satellite telemetry modem/GPS, and a small processor to provide commands to steer the system via a rudder on the glider. The wave glider has demonstrated the ability to "swim" thousands of kilometers to/from a location and to hold station in a very small watch circle for two years. We will leverage the talents and strengths of Liquid Robotics, to tow a modern, seafloor seismic package based on the current Scripps broadband ocean bottom seismograph to the desired site. The glider will then circle the above the launch site to act as a surface gateway between the acoustic transmission through the ocean column and satellite transmissions to shore.

While this talk specifically addresses a global seismic network, the capability can be broadly applied to other scientific problems including the monitoring of ice sheet and shelf breakup and telemetering data from many other types of seafloor and water column sensors. The life cycle costs for this system will be much less than the cost of maintaining buoys, with accompanying tethers, for scientific observations including climate.