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A low-power tool for measuring acceleration, pressure, and temperature (APT) with wide dynamic range and bandwidth

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We present a new tool that facilitates the study of inter-related geodetic, geodynamic, seismic, and oceanographic phenomena. It incorporates a temperature compensated tri-axial accelerometer developed by Quartz Seismic Sensors, Inc., a pressure sensor built by Paroscientific Inc., and a low-power, high-precision frequency counter developed by Bennest Enterprises Ltd. and built by RBR, Ltd. The sensors are housed in a 7 cm o.d. titanium pressure case designed for use to full ocean depths (withstands more than 20 km of water pressure). Sampling intervals are programmable from 0.08 s to 1 hr; standard memory can store up to 130 million samples; total power consumption is roughly 115 mW when operating continuously and proportionately lower when operating intermittently (e.g., 2 mW average at 1 sample per min). Serial and USB communications protocols allow a variety of autonomous and cable-connection options. Measurement precision of the order of 10-8 of full scale (e.g., pressure equivalent to 4000 m water depth, acceleration = +/- 3 g) allows observations of pressure and acceleration variations of 0.4 Pa and 0.3 μm s-2. Long-term variations in vertical acceleration are sensitive to displacement through the gravity gradient down to a level of roughly 2 cm, and variations in horizontal acceleration are sensitive to tilt down to a level of 0.03 μrad. With the large dynamic ranges, high sensitivities and broad bandwidth (6 Hz to DC), ground motion associated with microseisms, strong and weak seismic ground motion, tidal loading, and slow and rapid geodynamic deformation - all normally studied using disparate instruments - can be observed with a single tool. Installation in the marine environment is accomplished by pushing the tool roughly 1 m vertically below the seafloor with a submersible or remotely operated vehicle, with no profile remaining above the seafloor to cause current-induced noise. The weight of the tool is designed to match the sediment it displaces to optimize coupling. An initial deployment of the first instrument constructed began in September, 2015, with a connection to the Ocean Networks Canada NEPTUNE observatory cable to study interseismic deformation of the Cascadia subduction zone. Examples of oceanographic, seismic, and geodynamic signals are presented from the first six months of monitoring. New instruments are under construction for earthquake and geodynamic monitoring using the ONC/NEPTUNE cable system, and for multi-year autonomous operation to study episodic slow slip at the Hikurangi subduction zone.
Additionally, we will highlight a new technique to determine long period seafloor deformation from broadband seismometer mass-position measurements.