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# Retrieve Ocean Bottom and Downhole Seismic sensors orientation using integrated low cost gyroscope and direct rotation measurements

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To reduce the background noise level, seismic sensors are often installed in downhole. During the installation, it is not possible to determine exactly what the sensors has rotated in the horizontal plane before reaching the bottom. To monitoring the seismic activity occurred in offshore areas, Ocean Bottom Seismometers (OBS) are often deployed in the area to be studied. During the OBS descent phase along the seawater column the sensor can undergo to significant rotations in the horizontal plane.
Therefore, both for seismic sensors installed in downhole or on ocean bottom, the absolute orientation of the horizontal components are unknown. Clearly, this serious problem can be limits data analysis and interpretation. The absolute orientation of horizontal components are critical for many modern seismic analysis techniques such as receiver functions, body- and surface-wave polarization analysis, studies of anisotropy, and surface wave dispersion curves estimations. The techniques proposed to retrieve the correct sensor horizontal components orientations use different approaches (polarization analysis, cross-correlation measurements, synthetic seismograms fitting), different data set (shots, earthquakes, seismic noise) and different portion of the seismic wave-field (P or S wave arrival times, Rayleigh waves, full waveforms), but are all based on the post-processing of the acquired data. All these methods are not error-free and not always applicable. Method based on active source are not applicable in passive OBS monitoring campaigns. The method based on synthetic waveforms are strong dependent on accuracy of the source parameters estimation and are generally computationally intensive. The method based on polarization analysis are clearly strong dependent on the quality of the data in term of number of seismic events recorded, azimuthal coverage and signal to noise ratio. The methods base on events or noise cross-correlation can be applicable only if an array of sensor is deployed, but are not applicable to individual sensors or sensor-very far from each other.
For all the above reasons it would be desirable a direct determinations of absolute orientation of horizontal components, not dependent on the nature, quantity and quality of the data acquired. The simplest solution to the problem would be the installation together with the sensors of an electronic compass able to directly measure the real horizontal orientation of the seismometer. However, as well known, all seismic sensors currently used to record earthquakes, produces strong electromagnetic fields which make data recorded by an electronic compass placed in their proximity unusable for the described purpose.
For this reason, in this work, we propose a method for the estimation of the absolute orientation of horizontal components of a seismic sensor based on the use of a Micro Electro-Mechanical Systems (MEMS) gyroscope. MEMS gyroscope are low-cost electromechanical devices able to measure angular rate. The results of several tests have shown that these devices can allow an accurate determination of sensor orientation, better than that determined by post-procesing techniques. The small size, low power consumption and cost make these devices suitable in down hole or ocean bottom seismology.