Variability in Seafloor Pressure from Ocean and Atmospheric Effects at the Mexico Subduction Zone offshore Guerrero

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Recent studies in the field of marine geodesy have aimed to measure the crustal deformation of the seafloor using absolute pressure gauge measurements. The records from ocean bottom pressure (OBP) instruments installed at temporary stations around subduction zones have been demonstrated to contain signals related to the uplift or subsidence occurring underneath them. However, obtaining accurate values of the vertical component of solid earth deformation requires removing the pressure signals due to the response of the overlying water column to phenomena in the ocean and atmosphere. If multiple OBP instruments were deployed in an array configuration, and under the assumption that the effects from ocean circulation are coherent across the deployment area over a range of time scales, then differencing the pressure records between stations may remove a common-mode signal related to oceanic variability. Then, if one or several OBP stations are at locations with no expected crustal deformation, then these can be used as reference sites for obtaining the relative vertical displacement at a station of interest.

The analysis of such station-to-station OBP residuals requires prior processing of the data to separate the tidal signal, primarily at the diurnal and semi-diurnal periods. This can be accomplished by applying a low-pass filter to the data, and in previous research, this has been sufficient to allow for the observation of seafloor deformation due to slow slip events that with a duration at the time scale of several weeks. On the other hand, shorter transients may be obscured when using this filtering approach. In this work, we develop and test methods of OBP data processing for the purpose of isolating the signal from seabed displacement by identifying sub-daily fluctuations in pressure from variability in the seawater layer.

The OBP data we use in this study was collected as part of an amphibious array deployment of seismic and geodetic instruments which focused on a region along the coast of Guerrero, Mexico facing the Pacific Ocean. The study area is located within a segment of the Mexico subduction zone offshore where various geophysical phenomena such as slow slip events and tectonic tremor have been previously identified, but primarily onshore. The OBP stations were installed at offshore sites on the continental margin as well as the incoming oceanic plate and were recording data for an approximately 1-year long period from November 2017 to November 2018.

Before performing harmonic analysis of the tidal components of the OBP measurements, the data are sub-sampled to 1-hour intervals. Then, the hourly data are used as input in the BAYTAP08 software, which employs Bayesian modeling techniques to determine the significance of each tidal constituent to be predicted for the input data. In addition, we also conduct a power spectral analysis of the OBP data from the Guerrero stations.

Peaks are found in the power spectral density of the original OBP data around the diurnal and semidiurnal periods, corresponding to the signal from the major tidal constituents. Upon subtraction of the BAYTAP08-modeled tides from the OBP data, there remains some residual energy around the semi-diurnal period. This remaining signal could possibly be connected to the solar tidal constituents. These include the solar diurnal (S_1) and the solar semi-diurnal (S_2) tides, also referred to as "atmospheric tides" since they arise as a result of the daily cycle of the heating of the atmosphere by solar radiation. When sea surface height responds isostatically to atmospheric pressure fluctuations through the "inverse barometer (IB)" effect, then there is no net change in the recorded ocean bottom pressure. Deviations from this IB response can occur, and moreover, the atmospheric pressure variations at the S_2 period can further excite fluctuations in the ocean layer, creating a broad peak in the power spectra. In a further attempt to remove the remaining variability in the pressure data at ~12-hour periods, we tested the singular spectrum analysis (SSA) method on the de-tided records. The SSA technique is a nonparametric spectral estimation procedure, which can separate a time series into multiple components that represent oscillatory modes. Our preliminary results using SSA show that the sub-daily variability around the semi-diurnal period in OBP data can reach several hectopascals in amplitude. Such signals may hinder the observation of seafloor displacements of just a few centimeters if these occur rapidly.