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Identifying and Removing Current- and Wave-Generated Noise from Low Frequency (<0.1 Hz) Seafloor Seismic Data

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We demonstrate how to identify and remove low frequency noise caused by seafloor currents and ocean surface gravity waves on the vertical channel of a broadband ocean bottom seismometer. The currents tilt the instrument to create noise that depends on how well the instrument is leveled, and the waves generate seafloor motion that depends on the sediment/crust softness. The tilt effect can be avoided by burying or precisely leveling (to less than 0.02 degrees from vertical) the seismometer. Tilt noise is identified by its slope ($\sim f^{-1.5}$) and the correlation of its amplitude with ocean tides. Tilting generates low frequency seismic noise by changing the orientation of the earth's gravitational attraction on the geophones. The effect is much stronger on the horizontal components than on the vertical, allowing us to remove most of the vertical noise by subtracting the coherent horizontal component noise. Horizontal tilt noise will be much harder to remove. Wave-generated noise varies less over time and cannot be avoided by burying the seismometer. It is identified by its peak at the frequency where ocean surface gravity waves have a wavelength ~4 times longer than the ocean depth (for example, 0.009 Hz in 4 km deep water). This noise can be removed by calculating the pressure/vertical transfer function and then subtracting out the pressure effect on the vertical signal. In theory the waves also create a horizontal noise, but in practice this noise is overwhelmed by the horizontal tilt noise. After removing both effects, the background vertical seismic noise is between 10^{-15} and 10^{-16} $(m/s^2)^2/Hz$ in the frequency range 0.003-0.1 Hz, 20-40 dB lower than the measured noise level at typical seafloor sites and below the noise level of many “broadband” OBS. We will show examples of seafloor background noise and teleseismic earthquake recordings at several sites before and after removing the tilt and wave noise, and we will discuss the effect of site selection, noise removal, and geophone quality on seafloor seismic data quality.