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Large scale forces under surface gravity waves at a wavy bottom: a mechanism for the generation of primary microseisms

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Primary microseisms are background seismic oscillations recorded everywhere on Earth with typical frequencies $0.05 < f < 0.1$ Hz. These are generated by ocean surface gravity waves of the same frequency f, propagating over shallow bottom topography. Wave-induced pressure at the seafloor creates horizontal and vertical forces that oscillate in time, at the frequency of the surface gravity waves, containing wavelengths that can match those of seismic waves. Previous quantitative models of this process, considering large scales topographic features, require unrealistic bottom slopes of 3 to 6% to match observed seismic amplitudes. Here bottom features with smaller horizontal scales, equal to those of the ocean surface waves, are considered. Forces at wavenumber vector are found to result from interactions of the surface waves of wavenumber and bottom topography of wavenumber $_b$ such that $= +_b$. For $|| \ll ||$, these forces can generate seismic waves. Spectra of seismic motions can be computed from the spectra of these forces. This is illustrated with Rayleigh waves on the West coast of Ireland, using measured bottom topography and modeled ocean wave properties. A realistic rough bottom over an area of 100 km^2 in 15 m depth is enough to explain the vertical ground motions observed at a seismic station located 150 km away. The mechanism investigated here is a plausible explanation for seismic signals measured at frequencies around 0.06 Hz.