The Origin of Deep Ocean Microseisms in the North Atlantic Ocean

Sharon Kedar
Jet Propulsion Laboratory

Oceanic microseisms are small oscillations of the ground, in the frequency range of 0.05-0.3 Hz, associated with the occurrence of energetic ocean waves of half the corresponding frequency. In 1950, Longuet-Higgins suggested in a landmark theoretical paper that (i) microseisms originate from surface pressure oscillations caused by the interaction between oppositely travelling components with the same frequency in the ocean wave spectrum, (ii) these pressure oscillations generate seismic Stoneley waves on the ocean bottom, and (iii) when the ocean depth is comparable with the acoustic wavelength in water, compressibility must be considered. The efficiency of microseism generation thus depends on both the wave frequency and the depth of water. While the theory provided an estimate of the magnitude of the corresponding microseisms in a compressible ocean, its predictions of microseism amplitude heretofore have never been tested quantitatively. In this paper, we show a strong agreement between observed microseism and calculated amplitudes obtained by applying Longuet-Higgins' theory to hindcast ocean wave spectra from the North Atlantic Ocean. The calculated vertical displacements are compared with seismic data collected at stations in North America, Greenland, Iceland and Europe. This modelling identifies a particularly energetic source area stretching from the Labrador Sea to south of Iceland, where wind patterns are especially conducive to generating oppositely travelling waves of same period, and the ocean depth is favourable for efficient microseism generation through the 'organ pipe' resonance of the compression waves, as predicted by the theory. This correspondence between observations and the model predictions demonstrates that deep ocean nonlinear wave-wave interactions are sufficiently energetic to account for much of the observed seismic amplitudes in North America, Greenland and Iceland.