Numerical modeling of microbarometric and microseismic oscillations due to ocean surface waves

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Ocean surface waves (OSWs) shake the atmosphere on sea surface and the crust on sea bottom. In order to estimate the amplitude and the propagation directions of the OSWs from the observes oscillations, we need to quantify (1) the amplitude and the propagation directions of the oscillations excited by the OSWs, and (2) the variation of the amplitude after their propagation to observation points. The quantification of (1) have been almost completed by previous mathematical studies: The excited oscillation amplitude is in proportion to the product of two OSWs' and the frequency and wavenumber are the sum of the OSWs’. Here the OSWs need to propagate in the nearly opposite directions, to have nearly the same wavelengths, and to interact nonlinearly. A recent study showed that ocean compressibility is needed for seismic body wave excitation [Ardhuin and Herbers, 2013 (AH2013)]. The quantification of (2) by mathematical approaches are, however, not so easy because it deals with many inhomogeneous and uncertain parameters such as atmospheric wind and temperature, and crust density. In such complicated conditions numerical approaches are more useful. In this paper, we develop a numerical model to quantify both (1) and (2), and validate the model. In our model, the atmosphere, ocean and crust are treated as as a single continuum and described by nonlinear and compressible equations. As the validation we impose two OSWs traveling in the opposite directions and having almost the same frequency and wavelength, analyze the resultant atmospheric and seismic oscillations, and compare them with AH2013. Our analysis shows that the imposed OSWs excite acoustic waves in the atmosphere and in the ocean. The frequency and the wavenumber of the acoustic waves are the sum of the OSWs’. The oceanic acoustic waves propagate to the ocean bottom to excite seismic surface waves with the same frequency and wavelength. In the crust seismic body waves are also excited. The excited amplitudes are consistent with AH2013.

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