津波と津波が励起する大気ラム波の振幅の関係についての数値的理論的考察

Numerical and Theoretical Study on the relationship between the amplitudes of tsunamis and the associiated atmospheric Lamb waves

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Major tsunamis excite significant atmospheric Lamb waves, i.e. low frequency ground trapped atmospheric waves that propagate with acoustic wave speed, and their signals can be useful for the inversion of tsunami sources (e.g. Arai et al 2011; Mikumo et al 2008). Here I will discuss (i) the result of numerical experiments on the response of compressible atmosphere to the vertical motion of ground surface representing tsunamis, (ii) its theoretical interpretation, and (iii) the suggested high potential as a practical tool for quantitative prediction of tsunamis.

The numerical experiment shows that three kinds of waves are excited responding to tsunamis, which are, acoustic waves that propagate upward with the speed of sound, internal gravity waves that propagate horizontally with the speed much slower than the speed of sound, and, Lamb waves that propagate horizontally with the speed of sound being trapped near the ground surface. Notably, it is shown that the pressure amplitudes and waveforms of the Lamb waves almost "duplicate" the heights and waveforms of tsunamis, being almost insensitive to the rise time of the tsunamis unless it is shorter than a L_t/c_s, where L_t is the length scale of tsunamis and c_s is the speed of sound. This last property is distinctly different from the traditionally used scaling for pressure amplitude of tsunami-induced infrasound waves, which has been haunted by the dependence on vertical velocity of tsunamis that is hard to obtain quickly.

The excitation property of Lamb waves can be understood in a straightforward manner considering the state of the atmosphere after "hydrostatic adjustment" (e.g., Bannon, 1995) in response to the uplift of lower boundary; the entire atmospheric column is lifted upward by the same amount to the rise of sea surface. Based on the theoretical consideration, one can derive a set of equation that can predict the excitation and propagation of tsunami induced Lamb waves. It is highly economic, being two-dimensional equations, and, at the same time, is capable of quantitatively reproduce the observed waveforms of pressure disturbances excited by major tsunamis.

The results indicate pressure measurement of Lamb waves is very useful for the prediction of tsunamis, including those excited by slow fault motions that are hard to be captured by conventional seismometers.

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