Paper 1

Abstract

A viscoelastic model is proposed to describe the propagation of gravity waves into various types of ice cover. The ice-ocean system is modeled as a homogeneous viscoelastic fluid overlying an inviscid layer. Both layers have finite thickness. The viscosity is imagined to originate from the frazil ice or ice floes much smaller than the wavelength, and the elasticity from ice floes which are relatively large compared to the wavelength. A compact form of the dispersion relation is obtained. Under proper limiting conditions this dispersion relation can be reduced to several previously established models including the mass loading model, the viscous layer model and the thin elastic plate model. The full dispersion relation contains several propagating wave modes under the ice cover. The following two criteria are used to select the dominant wave mode: (1) wave number is the closest to the open water value and (2) attenuation rate is the least among all modes. The modes selected from those criteria coincide with the ones discussed in previous studies, which are shown to be limiting cases in small or large elasticity regimes of the present model. In the intermediate elasticity regime, however, it appears that there are three wave modes with similar wavelengths and attenuation rates. Implications of this intermediate elasticity range remain to be seen. The general viscoelastic model bridges the gap among existing models. It also provides a unified tool for wave-ice modelers to parameterize the polar regions populated with various types of ice cover.

Citation

Wang, R., and H. H. Shen (2010), Gravity waves propagating into an ice-covered ocean: A viscoelastic model, J. Geophys. Res., 115, C06024, doi:10.1029/2009JC005591.

Paper 2

Abstract

In order to model the wave-in-ice climate on a geophysical scale, a continuum viscoelastic model has been developed [Wang, R., Shen, H.H., 2010. Gravity waves propagating into an ice-covered ocean: a viscoelastic model. J. Geophys. Res. 115, C06024. doi:10.1029/2009JC005591]. In this model, two modes were identified to be dominant, each for the low or high elasticity range, respectively. In the intermediate elasticity range, both modes have comparable attenuation rates and wave numbers, and they could be co-dominant. Inspired by the Eigenfunction Expansion Matching Method, this paper presents an approximate approach to solve the wave propagation characteristics in the whole physical range of elasticity. A monochromatic wave propagating from semi-infinite open water into semi-infinite ice-covered water is considered. Only two transmitted wave modes are included in the eigenfunction expansions for the ice-covered water. These two modes correspond to the dominant mode under relatively low or high elasticity, respectively. Evanescent wave modes in open water are ignored. By

minimizing the matching errors, the least square solution is obtained. For the pure elastic ice cover, the results are compared with the exact solution from the thin elastic plate model. The comparison is in good agreement when the wave period is larger than 10 s. Mild discrepancies exist when the period is smaller than 10 s. The present model provides the simplest way to describe wave propagation characteristics in different types of ice covers.

Citation

Wang, R. and Shen, H.H. (2011) A continuum model for the linear wave propagation in ice-covered oceans: an approximate solution, Ocean Modelling, 10.1016/j.ocemod.2011.04.002