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Trapped and internal waves in ice-covered seas

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Edge waves on ice-covered water were analyzed using linearized theory for a plane-sloping beach with a straight coastline. These waves propagate along the coast and have an amplitude, which decays exponentially away from the shoreline. The problem is examined without the hydrostatic assumption. The sea water is considered homogeneous, inviscid, non-rotating, and incompressible. The ice is considered of uniform thickness, with constant values of Young's modulus, Poisson's ratio, density and compressive stress in the ice. The boundary conditions are such that the normal velocity at the bottom is zero and at the undersurface of the ice the linearized kinematic and dynamic boundary conditions are satisfied. We present and analyze explicit solutions for the edge flexural-gravity waves and the dispersion equations. The ice cover significantly influences the characteristics of edge waves in the domain of short waves (tens of and a few hundred meters). For long waves (one thousand meters and longer), its role is not significant. At fixed wavelengths, the velocity of the propagation of such waves is always smaller than the velocity of flexural gravity waves in a sea of infinite depth. The existence of the ice cover leads to a more complex dependence of ice deflections on the coordinate normal to the coast, especially in the domain of small periods of edge waves. In particular, under the ice conditions, the amplitude of the nonzero-mode edge waves at the coast exceeds the amplitude of similar waves in the ice-free period, while the maximum of the amplitude can occur at a distance from the coast.

Kelvin and Poincare waves in ice-covered water were analyzed also in the linearized theory. The problem is examined without making a long-wave approximation. The sea water is considered homogeneous and inviscid. The ice is taken as of uniform thickness, with constant values of Young's modulus, Poisson's ratio, density and compressive stress in the ice.We found explicit solutions for Kelvin and Poincare waves under an ice cover and the dispersion equations.

A theoretical model describing propagation of internal waves under ice cover in the ocean of constant depth was developed. The Brunt–Vaisala frequency was assumed constant. According to the results obtained, the oscillations of the ice surface with the frequency close but smaller than the Brunt–Vaisala frequency can have amplitudes sufficient for recording internal waves. In particular, this means that application of rigid lid approximation for vertical velocity in the problems with ice can lead to wrong conclusions. It is better to use a weaker approximation of rigid lid when vertical pressure gradient at the lower boundary of the ice surface is assumed zero. Measurements of internal waves in a shallow arctic fjord Van Mayen, Svalbard, demonstrated that fluctuations of temperature and velocity with a period of approximately 10 minutes and internal wave amplitude of 1 m correlate with the fluctuations of the ice cover of the same period with an amplitude of a few millimeters. These results agree with the theory.