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Underwater Ambient Noise as Indicator of the Dynamic Processes in the Arctic Sea Ice Cover

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ABSTRACT

It is known that a stressed state of ice cover appears due to the inner transfer of wind and water pressure through ice. Ice movement observed in some one point depends not only on force acting in this point, but on forces acting in all surroundings. Using drifting stations with special devices there is the possibility to estimate causal dependence between a stressed state in some local point and stress fields in large areas. Upon analyzing 4 equations for 4 characteristics of spatial irregularity of ice drift, it is found that ridging of ice can be connected with drift divergence or with deformation. This is because any change in the form of an ice cover element must be accompanied by regrouping of ice floes and their clash if ice concentration is enough. Dynamic phenomena in ice cover lead to specific acoustic noise under the ice. Knowing the statistical dependence of the acoustic pressure in water on wind velocity, ice drift, air temperature, deformation, divergence and other parameters and their derivatives, the equation of multicorrelation can be obtained, and it can be used for estimation of the stressed state of the ice cover.

INTRODUCTION

The only acoustic waves are irradiation which is able to propagate through the sea for a long distance. They give essential information about the state of the water body and neighbouring surroundings. Characteristics of underice noise associate close to the processes in the ice cover and its boundaries. A large changeability of ambient noise of the Arctic Ocean (depending on the region of measurements, time interval of the year and day, hydrological and meteorological conditions) caused a necessity of multiple measurements in the different regions of the Arctic basin and for different seasons. For some decades such studies have been carried out both by Russian and American investigators. Mainly these works were at the order of their corresponding military departments although it was evident even then that the characteristics of the Arctic underice ambient noise (as geophysical phenomena widespread in the regions of economic activity of the people in the Northern Hemisphere) can be interesting for other (not military) departments. There are many publications in which results of these investigations are discussed. Some of them show that the main sources of underice noise are the dynamic interaction of floes causing their destruction (Bogorodsky et al., 1969), thermal cracking of ice (Ganton and Milne, 1965), wind influence on the ice-snow surface (Milne, 1966; Lebedev and Popov, 1971) and surface of leads (Green and Buck, 1964), natural vibrations of the ice cover (Sytinsky and Tripolnikov, 1964; Leshack and Haubrich, 1964), and sea organisms (Bogorodsky and Lebedev, 1978). The most powerful source is ridging of pack ice (Bogorodsky and Gusev, 1973).

Basing on analyses of numerous measurements it was found that the noise characteristics of the summer period differ from winter ones. A large area of open water (leads, snowflakes) is characteristic for the summer period. During this time intensive ridging is rather rare; wind wave formation and impacts of waves on the ice banks of leads and snowflakes are the main source of noise in the sound frequency range. The greatest quantity of ridging is observed during the stable negative temperature when a thin ice of frozen leads is ridging. During a quick lowering of air temperature (more than 1°/h) the brittle surface cracks can form in thicker ice cover.

These cracks generate specific impulse noise of increased level. However such noise usually takes place only when the air temperature is about –20 C and lower (Milne, 1966; Gavrilo et al., 1970). In winter, wind causes transferring of snowflakes accompanied by their saltation and whirlwind formation on rough ice cover. These processes add sources of ambient noise. The "wind" part of noise raises its level mainly within the 1-5 kHz range, but an increase of spectral level in the range of tenths of hundreds cycles/s characterizes the ambient noise caused by cracking activity of ice because of its rupture. Mixing of wind noise and noise due to ridging is the reason of multiform spectrums for the sound frequency in the 20-15000-Hz range. During organization of long-term measurements of noise characteristics at one point, of course the aim was not only to know the mechanism of sound formation, but also to reveal particular statistical dependencies of water sound pressure at a different frequency band for different meteorological parameters. For instance, the work of Bogorodsky et al. (1972) discusses such air temperature and wind velocity dependence of underice noise level for the 100-400-Hz band on air temperature and wind velocity in the case when thermal cracks have been appearing in the 3-m-thick ice cover.

The aim of this paper is presentation of some results of the analysis of the physical-statistical connection of root mean square underice noise levels within the 20-100-Hz band with wind velocity and characteristics of spatial irregularity of ice drift. These characteristics have been analyzed in comparison with synoptic situations using experimental data obtained in 1966-67 in the drifting station NP-15 region when synchronized observations were organized simultaneously at several points spaced at the distance determined by spatial correlation radii of the hydrometeorological fields. In connection with this was an interesting answer to the question: Can we in a way describe processes of divergence and convergence of the ice cover having characteristics of underice noise?

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