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Development of an Arctic Low Frequency Ambient Noise Model

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LONG-TERM GOAL

Our long-term goal is to develop a low frequency ambient noise model capable of predicting extreme (loud/quiet) noise events in Arctic ice-covered waters due to the presence or absence of storms.

OBJECTIVES

We wish to determine the internal stress of the ice canopy covering the Arctic ocean due to convergent atmospheric forcing and relate this to energy dissipation rate due to ridge building, the major source of ambient noise in the frequency regime under consideration.

APPROACH

We plan to use the Navy's Polar Ice Prediction System (PIPS) to determine the ice stress and energy dissipation rate over the ice-covered Arctic Ocean on a daily basis. The energy dissipation rate due to intense ice fracturing (ridge building) caused by migrating polar storms will be related to the source level of the ambient noise based on noise data acquired by ice-mounted drifting buoys. The source level density (per unit area) will then be propagated to randomly placed distant receivers using the modified Ambient Noise Directional Estimating System (ANDES) to calculate the noise field. High resolution SAR imagery will provide a quantitative representation of the number and spatial density of newly created pressure ridges which we assume are directly related to the increase in ambient noise due to storm forcing.

WORK COMPLETED

The Navy's Polar Ice Prediction System (PIPS) was modified by Bill Hibler (now at University of Alaska) to calculate the energy dissipation rate, due to shear and dilatational stresses. Ruth Preller and Pam Posey at NRL/SSC provided 12-hourly output fields of energy dissipation rate for the entire Arctic basin for the period Nov 1997 to June 1998. We have acquired RGPS ice deformation images from Ron Kwok at JPL for this same time period. These images are currently available only for the immediate vicinity of the SHEBA site in the Beaufort Sea. We have acquired ambient noise data from two drifting buoys near the SHEBA site (courtesy of Jim Parinella of Scientific Solution, Inc.) for the Nov-June 1998 period. The noise data have been edited and their spectra (from 50 Hz to 1000 Hz) analyzed. Correlations with wind speed, wind stress and ice motion are currently being performed. Preliminary analyses of concurrent ambient noise data, RGPS images and PIPS energy dissipation fields have demonstrated the viability of our modeling approach.

RESULTS

The ambient noise spectra at low frequencies (<200 Hz) measured during the SHEBA experiment are 10 dB (5 dB) lower in winter (summer) than recorded by drifting buoys in the Beaufort Sea in 1985-6. This may be due to reduced atmospheric forcing in 1997-8 as reported by the SHEBA scientists or due to the much thinner ice cover during SHEBA. Few strong wind and ambient noise events were recorded during the SHEBA experiment.

The local RGPS images (200 km² region centered on the SHEBA site) often show limited or no ice deformation occurring at times of high noise levels. These high noise levels are associated with the arrival of low frequency acoustic energy being propagated in from remote (several hundred kilometers) areas identified on the PIPS plots as regions of high energy dissipation rate due to the presence of cyclonic storms. This points up the need for basin-wide atmospheric forcing, not local wind speeds, in order to properly model/forecast low frequency noise levels.

IMPACT/APPLICATIONS

Our model output is designed to assist submarines when operating beneath the Arctic ice cover. Submarine tactics related to detection/counter detection are strongly dependent on the magnitude of the noise field.

We have also demonstrated that a high resolution, directional ambient noise model can be used inversely to locate regions of high ridging intensity which has operational significance for submarines. In addition, the new PIPS 3.0 model, with its high resolution energy dissipation and divergence fields, should be able to identify regions of open water/thin ice and ridge formation. Knowledge of the areal extent of such features should provide more accurate estimations of the atmosphere-ice-ocean heat exchange as well as direct operational support to submarine, ice camps, etc.

TRANSITIONS

None at the moment, but great potential exists for creation of an operational forecast for ice-covered waters.

RELATED PROJECTS

Our modeling effort is indirectly related to the larger scale project to replace and dramatically improve the current PIPS model. This improved model, known as PIPS 3.0, is a community effort lead by Bert Semtner at NPS and Ruth Preller at NRL/SSC. The greater spatial resolution and use of an ice thickness distribution algorithm should greatly improve estimates of the energy dissipation rate.

Ron Kwok at JPL is currently developing basin-wide images of ice deformation for the SHEBA time period which will enable us to examine the impact of distant storms on the local ambient noise field.

PUBLICATIONS

Bourke, R. H., D. Feller and J. H. Wilson, Ambient Noise Characteristics of the Nansen Basin, submitted to J. Acoust. Soc. Am., 1999.