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A depth, range, and time probability distribution of intensity for wave propagation in random media FREE

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trends of the magnitudes and phases as well as the dependence of the incremental dispersion on both range and frequency. a) Visiting from Department of Mathematical Sciences, Loyola University, Chicago, IL.

9:50

EE6. Angular dependence of under ice reflectivity in the marginal ice zone (MIZ). Patricia L. Gruber and Ronald L. Dicus (Code 5120, Naval Research Laboratory, Washington, DC 20375)

Acoustic reflectivity measurements from sea ice in the MIZ were taken during MIZEX-84. Signals from explosive charges (MK-61 and -82 SUS) received on 12 hydrophones of a 313-m vertical array were processed to separate single bounce ice reflections from direct path and bottom reflected arrivals by replica deconvolution. Ice reflection loss was computed from the ratio of reflected energy to direct path energy after correction for spreading loss differences between the two paths. Signals from different source ranges and receiver depths were collected on the basis of their specular reflection grazing angles spanning the interval 10° to 30°. Data points with estimated standard deviation of reflectivity greater than 0.2 (based on noise estimates) were excluded. The resulting reflectivity versus grazing angle curves at 64, 96, and 128 Hz displayed high variance presumably due to scattering from a single under ice pressure ridge within the Fresnel zone. With angular smoothing the curves showed small angular dependence and losses on the order of 1.5 dB. Comparison of results with model computations will be discussed.

10:05

EE7. A stochastic propagation and scattering operator for ocean propagation. C. C. Yang (Department of Electrical Engineering, Pennsylvania State University, University Park, PA 16802) and Suzanne T. McDaniel (Applied Research Laboratory, Pennsylvania State University, University Park, PA 16802)

General properties of acoustic propagation and scattering in a stochastic open environment are investigated. In this study, the positions of the source and observation points can be arbitrary. Furthermore, these two points can be in relative motion. The most important factor of the ocean environment affecting wave propagation is the sound-speed profile. Also, because of the fine structure in temperature, stochastic fluctuations of the sound speed may exist along the paths of a sound wave. Therefore, effects from random scattering have to be taken into account. Because of the existence of the sound-speed profile in the ocean, more than one path may be drawn to connect the source and observation points. This multipath effect, including that due to the correlations among these paths, is fully discussed. To make computations feasible, the path integral technique is applied. [Work supported by ONR.]

10:20

EE8. The effect of an El Niño/Southern Oscillation event on underwater sound propagation. D. R. Palmer, L. M. Lawson, Y.-H. Daneshzadeh, and D. W. Behringer (National Oceanic and Atmospheric Administration, Atlantic Oceanographic and Meteorological Laboratory, 4301 Rickenbacker Causeway, Miami, FL 33149)

From June 1981 through June 1984, 15 separate ocean cruises were made to the equatorial Pacific to collect hydrographic data at 85°W as part of a NOAA climate program. The most recent El Niño/Southern Oscillation (ENSO) event occurred during this period. Temperature and salinity data obtained during the cruises have been processed and merged with archival data to form a series of sound-speed profiles which reflect the onset, evolution, and cessation of the ENSO event. By using computer models, with these profiles as input data, it is shown that propagation conditions fundamentally changed as a result to the ENSO event. Conditions which support a convergence-zone structure for a shallow source disappeared during the event resulting in bottom-limited propagation. While this severe change provides an opportunity to detect and monitor ENSO events using underwater sound, it prevents the straightforward application of acoustic tomography to obtain the temperature field and, hence, to study the dynamics of the event. For a source located at middepth, however, tomographic techniques may be applicable since propagation conditions are not as changeable there.

10:35

EE9. An analysis of the temporal fluctuations of cw acoustic propagation in the marginal ice zone. Peter H. Dahl, Arthur B. Baggeroer (MIT/WHOI Joint Program in Oceanography, MIT, Cambridge, MA 02139), and Peter N. Mikhalevsky (Science Applications International, Falls Church, VA 22046)

Continuous wave (cw) acoustic transmission data from MIZEX 84 (marginal ice zone experiments) were transmitted between two ships separated by approximately 100 km and propagated via a partially ice-covered path. The signals were stepped in frequency between 25 and 200 Hz for 1 h. Both vessels were drifting freely which resulted in a Doppler shift in the received multipath signal. The measured Doppler compares favorably with available navigational data. The quadrature demodulated received signal is modeled as a (locally) wide-sense stationary process. Accordingly, we can exploit the Gaussian correlation structure and estimate the moments of the power spectrum using the covariance method. This method is computationally efficient and relatively unexploited for this purpose. We relate the rms spectral width directly to the variance of the phase rate (ν^2). The value of ν^2 is a function of oceanic processes which dynamically perturb the sound field. Estimates of ν^2 from the MIZEX data are compared with similar experiments carried out in the more quiescent Central Arctic, and in midlatitude regions.

10:50

EE10. Low-frequency propagation across an East Greenland ice-edge eddy: Winter conditions. Leonard E. Mellberg (Naval Underwater Systems Center, Newport, RI 02841-5047), Ola M. Johannessen (Geophysical Institute, University of Bergen, Norway, N-5014), Donald N. Connors, George Botseas, and David G. Browning (Naval Underwater Systems Center, Newport, RI 02841-5047)

A series of small cyclonic eddies have been observed along the ice edge adjacent to the East Greenland current in the vicinity of the Fram Strait. These eddies are characterized by a unique spiral surface pattern as pack ice is drawn into the circulation. Melt water from this ice contributes to a complicated temperature-salinity structure. An analysis of low-frequency (50 Hz) propagation is presented using environmental range-dependent acoustic prediction models: parabolic equation (PE) and ray model [GRASS]. The environmental data are for winter conditions based on a longitudinal oceanographic transect. Results are compared to previous analyses of a similar eddy in the Fram Strait under summer conditions and the directional dependence of acoustic modes across the East Greenland current frontal zone. [Work supported by NUSC and ONR.]

11:05

EE11. A depth, range, and time probability distribution of intensity for wave propagation in random media. T. E. Ewart (Applied Physics Laboratory and School of Oceanography, University of Washington, Seattle, WA 98105)

The second moment of intensity as a function of depth, range, and time for WPRM can be modeled in terms of a space–time autocorrelation function, a scattering strength parameter γ, and a scaled range X. The higher moments have not been predicted for all γ and X; however, it is generally accepted that the intensity moments are lognormal at small X and exponential at large X. The generalized gamma distribution function (GGDF) [E. W. Stacy, Ann. Math. Stat. 33, 1187 (1962)] forms a large class that includes the lognormal and the exponential pdf's. It is proposed that the GGDF can model the probability distributions of intensity in forward scattering over wide ranges in γ and X. The temporal intensity fluctuations measured during MATE and depth-range results from Monte-Carlo simulations of WPRM for a medium with a power law autocorrelation function have been used to test the proposition. The "goodness of fit" of the GGDF's fitted to those data sets, and the benefits of using distribution modeling rather than intensity moment will be discussed. The results are convincing; it remains a nontrivial task to test the hypothesis theoretically. [Supported by ONR code 425OA.]

11:20

EE12. Observations of acoustic wave propagation in the Arctic Ocean—Preliminary results from AATE. Terry E. Ewart and S. A. Reynolds (Applied Physics Laboratory and School of Oceanography, University of Washington, Seattle, WA 98105)

Preliminary results are presented for the AIWEX acoustic transmission experiment (AATE). Pulsed tones at 2, 4, 8, and 16 kHz were transmitted from a fixed source to three depth cycling receivers for 12 days (spanning a depth of 150 m) and to a fixed receiver 100 m away (for the last 7 days). The plane of the four receivers was perpendicular to the transmission path. Extensive oceanographic measurements in the ray path region were made simultaneously as part of the Arctic internal wave experiment (AIWEX). The depth-time sampling of the acoustic field satisfied the Nyquist criteria. Preliminary analysis indicates a weak fluctuating environment. The acoustic phase is geometric with variations due mostly to the mean sound-speed profile. The internal wave field is weak, the amplitude and travel time fluctuations are much smaller than those observed in the open ocean, and the statistics are not stationary. These acoustic observations, where the statistics of the medium are well known, will provide a thorough test of available predictions of WPRM in depth, range, and time. [Supported by ONR code 425AR, NORDA, and Marconi Systems Ltd.]

11:35

EE13. Analysis of high-frequency cw tones propagated in the Arctic Ocean. Josko Catipovic and Arthur B. Baggeroer (MIT/WHOI Joint Program in Oceanography, MIT, Cambridge, MA 02139)

During the marginal ice zone experiment (MIZEX), measurements were made of the fluctuating phase and amplitude of a densely spaced set of tones centered around 50 kHz. Eight tones were transmitted simultaneously; the intertone spacing varied from 50 Hz to 1 kHz. The transmitter and receiver were located 10 m below the surface, immediately below the ice. The propagation path was approximately 1.5 km long. The received tones show extensive fading at time rates corresponding to mean drift which produces a nearly constant phase rate; ice motion at approximately 1/10 Hz; and internal waves at higher rates. The tone fading is nearly frequency independent at lower rates, but has a frequency correlation of several hundred Hertz at fade rates of approximately 1 s. The various rates of fluctuation are separated in the analysis to identify the generation mechanism. Envelope and phase amplitude analysis indicate a fully saturated path with most of the effect arising from the higher fluctuation rate. Time-frequency correlation of about 1 s and 300 Hz dominate. For underwater communications these results show that phase coherence at these frequencies is difficult to attain even at close ranges, and that the time-variant channel behavior requires either high coding levels or adaptive code selection or decoding for useful data transmission.

11:50

EE14. A relationship between ocean circulation and volume reverberation in the subarctic northeast Pacific Ocean (Gulf of Alaska). David G. Browning (Naval Underwater Systems Center, New London, CT 06320), R. G. Turner, and J. W. Powell (Defense Research Establishment Pacific, FMO, Victoria, BC, V0S IB0 Canada)

Earlier investigations have shown a significant change in integrated scattering [J. A. Scrimger and R. G. Turner, J. Acoust. Soc. Am. **54**, 483–493 (1973)] and spectral characteristics [R. P. Chapman *et al.*, J. Acoust. Soc. Am. **56**, 1722–1734 (1974)] when transmitting into the subarctic (above 40 north latitude) northeast Pacific Ocean. An analysis of an extensive series of volume reverberation measurements obtained by Turner indicates a strong influence of the counterclockwise circulation around the Alaskan Gyre on the distribution of scattering strengths. At higher frequencies (5–20 kHz) the greater scattering strengths are found in the relatively warm California undercurrent water which flows around the perimeter of the gyre. At lower (1.25–5 kHz) frequencies the greater scattering strengths are found in the relatively cold water such is found in the upwelled subarctic water at the center of the gyre. This implies a significant change in the type of scatterers between these frequency domains. [Work supported by ONT and DREP.]