A Practical Model for High-Frequency Seabed Bistatic Scattering Strength

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Abstract: A previously published model for bistatic scattering by elastic seabeds is extended to cases of larger roughness by replacing the rough-interface perturbation approximation with the small-slope approximation. Correlations between volume fluctuations of different types are considered, and it is shown that the effects of such correlations are more readily observed in bistatic scattering measurements as opposed to backscattering measurements. Finally, the importance of elastic effects in scattering by rocky seabeds is illustrated.

SILT EXAMPLE

As a first example, consider bistatic scattering for silts. The roughness contribution in this case can be shown to be small, and scattering is due to two types of volume inhomogeneity: spatial fluctuations of density and sound speed. The relative density fluctuations are chosen to be 10 times stronger, and both fluctuations are assumed to obey spatial “power law” spectra with exponent chosen such that the results are frequency independent. While power-law spectra are often used for fluid sediments, e.g., (1), the effects of cross-correlation between different types of perturbations have received little attention. To illustrate these effects, three cases have been considered: uncorrelated, positively, and negatively correlated density and sound speed fluctuations.

In Fig. 1, the angular dependence of the bistatic scattering strength is presented for these three cases for an incident grazing angle of 10°. The following effects are noteworthy:

- The effect of cross-correlation is small for backward directions, but is dramatically large for bistatic scattering angles in the range 120° to 180°.
- In the case of negative correlation, which is realistic for silts, there is very little scattering for angles around 165°. This behavior is due to the interplay of the two effects:
  - The density component contribution has a cardioid shape and is therefore generally small near the forward
direction.
- The sound speed component has a monopole angular dependence and therefore generally dominates near the forward direction.

When these components are of different sign, i.e., in the case of negative cross-correlation, a "no-scattering" angle appears due to destructive interference between the two different contributions.

ROCK EXAMPLE

Shear effects, which are important in rock, also produce interesting bistatic angular dependence. In the example presented in Fig. 2, volume scattering at a frequency of 30 kHz is treated using the formalism of (2-3) and roughness scattering is treated using the small-slope approximation in the form given by Yang and Broschat (4).

\[ I_i = g - 0.1 g_m p - 2 o \]

\[ \text{Roughness Only} \quad \text{Inc. Graz. Angle} = 20 \text{ deg} \]

\[ \text{Scattering Az.} = 180 \text{ deg} \]

**FIGURE 2.** Bistatic scattering strength for rock example.

Power-law spectra are assumed for both volume inhomogeneity and roughness, and only density fluctuations are taken to be non-zero. These fluctuations are weak in the sense that the dimensionless ratio of volume scattering cross section and compressional wave attenuation coefficient is 0.002. The shear parameters are taken from (3). Figure 2 shows that roughness scattering is dominant over the middle range of scattering grazing angles, but, surprisingly, volume scattering is dominant for low-angle backscattering and forward scattering, where shear effects are especially significant (3).

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REFERENCES