CONSIDERATIONS ON STOCHASTIC SOUND FIELD COMPUTATIONS

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Abstract

The problem is raised how to compute the average sound field and its variance given a stochastic ensemble of sound speed profiles

I. Introduction

The development of acoustic propagation models is more and more directed to account for the stochastic nature of the environment. This is because we have now fairly accurate models for the deterministic ocean which make us realise that the deterministic ocean is only an approximation to the real conditions and sometimes even an unrealistic one.

In this paper the stochastic nature of the environment is given by a stochastic ensemble of sound speed profiles. Under the assumption of stationarity we want to raise rather than solve the problem of how to compute the average sound field and it's variance given a stochastic ensemble of sound speed profiles and fixed other parameters. This problem is nontrivial because profile and field are not linearly related.

II. Averages of profiles and acoustic fields

1. General

Let $\rho_k(z)$ denote a measured sound speed profile of the ensemble. As input parameter for a model usually a smoothed version $\overline{\rho_k}$ is used to avoid spurious effects. Let $F(\rho_k)$ denote the acoustic field computed with some

deterministic model. Since we may generate a field for every k we have a set of fields. The conversion to decibels is denoted by $\log\{F(\bar{p}_k)\}$.
From this set of acoustic fields we may compute the ensemble average:

$$a = \langle \log\{F(\bar{p}_k)\} \rangle \tag{1}$$

and a variance

$$\sigma_a[\langle \log\{F(\bar{p}_k)\} \rangle] \tag{2}$$

On the other hand we may define from the ensemble of profiles the average profile $\langle p_k \rangle$, convert it into a smoothed version $\overline{\langle p_k \rangle}$ and compute the acoustic field

$$b = \log\{F(\overline{\langle p_k \rangle})\} \tag{3}$$

A stochastic sound propagation model provides us with a third type of acoustic field which uses as input parameter the profile $\overline{\langle p_k \rangle}$ and the variance $\sigma_p[\langle p_k \rangle]$:

$$c = \log\{F(\overline{\langle p_k \rangle}, \sigma_p)\} \tag{4}$$

2. Examples

Two ensembles of sound speed profiles were investigated. Both had an almost isothermal subsurface layer of high sound speed followed by a steep thermocline and an isothermal bottom layer of lower sound speed. The source was located at about half waterdepth which was for

ensemble No. 1 in the subsurface layer
ensemble No. 2 in the main gradient

Computations were done over a range of 30 nm.

For ensemble No. 1 the fields a, b, c differed less than $\sigma_a[a]$ which had a maximum value of 5 dB.

For ensemble No. 2 the fields a and b differed considerably less than $\sigma_a[a]$, however the field c looks already qualitatively different. The reason is that only a stochastic model can illuminate shadowed regions, i.e. model the leaking of energy through the steep gradient region.

III. Conclusion

It is noteworthy that inspite of the nonlinear relation between profile and acoustic field the levels of field a and b differ less than $\sigma_a[a]$ in every point in both examples. This is a valuable information on the sensitivity of the model with respect to the choice of the sound speed profile.

However since we know from comparison with the experiment that field c is the correct one, we have no longer an easy way to get information on the variability of the acoustic field. This information is already contained in the field.

The next step of this investigation will utilize the profiles $\overline{P_k}$ as input parameters for the stochastic model.