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# A theoretical formulation of a 3D acoustic propagation model for stratified oceanic media based on an indirect BEM approach.

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Despite the progress made both in hardware and numerical techniques, 3D acoustic propagation for stratified oceans in cartesian coordinates, is still a challenge. In 2019, an approach to this problem restricted to short-range distances, using the Boundary Element Method (BEM), was reported (Li et al. J. Comput. Phys. 392, (2019): 694-712.). The BEM is a widespread method that exhibits certain useful advantages for solving time-harmonic scattering problems such as the fact that only integration in 2D boundaries is required, the Sommerfeld radiation condition is automatically satisfied, there is no need to add artificial absorbing layers and the seawater-seabed interface can be managed quite easily. The main disadvantage is that a non-homogenous medium like the oceanic environment must be modelled as a multi-domain problem which makes it computationally expensive and big enough to require using of iterative solvers as the Generalized Minimal Residual Method (GMRES) in addition to techniques for accelerating the evaluation of surface integrals. Here, an indirect BEM formulation, characterized by providing a more stable solution than the direct approach adopted in the previously mentioned work, which needs preconditioners to solve the involved linear system, is developed from its theoretical foundations through numerical evaluation of some representative benchmark situations.

## Promotional text

Acoustic propagation modelling in the ocean is a key component to analize and understand received signals at hydroacoustic stations. Research on new improved methods, as the one presented here, is expected to generate further and direct impact on improving nuclear test monitoring

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