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Comparison of 2-D and 3-D finite-difference simulations for infrasound propagation in heterogeneous atmospheres

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Finite-difference methods are widely used to simulate infrasound propagation in the atmosphere. Flexibility of finite-difference scheme allows to implement highly heterogeneous media for sound propagation with complex source models. Full 3-D finite-difference methods have been utilized for local infrasound propagation with pronounced topography and showed that the 3-D nature of topography and weather conditions can affect infrasound propagation and waveforms significantly. In contrast, 2-D modeling has been preferred for regional and global propagation as full 3-D methods generally require enormous computational resources and time for simulations. In 2-D methods, 3-D features of medium variation are ignored or approximated by 2-D. However, it is not certain how accurate the 2-D approximation is for sound propagation in various conditions. In this study, we theoretically compare 2-D and 3-D finite-difference methods for infrasound propagation and evaluate the accuracy of 2-D approximation in various atmospheric conditions. The 2-D and 3-D comparison was performed using various methods (e.g., finite difference vs. PE method) for limited cases, but we use the exact same governing equation and high-order finite-difference scheme to exclude errors due to numerical methods. Our quantitative evaluation of the 2-D approximation will provide useful criteria to justify 2-D modeling for 3-D sound propagation.

E-mail

kim84@llnl.gov

Primary author: KIM, Keehoon (Lawrence Livermore National Laboratory)

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