Grant Training Center

1901 N Fort Myer Drive
Suite 1016
Arlington, VA 22209

NSF Grant

Project Summary

CAREER: Nonlinear internal wave breaking parameterized for linear models

The objective of this research is to parameterize internal gravity wave breaking due to common wave-mean flow interactions and incorporate the results into a linear modeling scheme. Results will impact the capacity of climate models to accurately describe large-scale processes due to unresolved internal wave propagation and breaking. Both main bodies of fluid in the environment, the ocean and atmosphere, are continuously, stably stratified (light over heavy). In such a situation, internal gravity waves may be generated by any disturbance to the stratification, in the same way waves are generated by a disturbance at the horizontal interface between two immiscible fluids of different density. These are dynamically different, though, because internal waves can propagate in three dimensions, transferring energy and momentum vertically and mixing pollutants and organisms throughout the medium. Wave breaking, resulting in mixing, is essential to driving large-scale atmospheric circulations and mixing heat and organisms to the deep ocean.

Intellectual merit Internal waves are constantly generated and dissipated throughout the ocean and the atmosphere. As they propagate they interact with other waves and larger-scale background circulations, exchang-ing their energy and momentum. Some of these interactions will increase the amplitude of the waves, which steepen and break, mixing the the fluid surrounding them. This mixing is necessary to carry heat to the deep oceans and pollutants away from near the earth’s surface. Strong breaking and dissipation in one location can also drive global scale motions. Through an accurate parame-terization of these processes, global climate models can more accurately predict future variations.

Methods for analysis will be theoretical, linear ray tracing, nonlinear numerical simulations, and experimental and observational comparisons. The result will be an efficient, effective means by which to estimate the propagation of an ensemble of waves through ocean and atmosphere envi-ronments. The information will be coordinated with current global circulation models for a more accurate parameterization of internal wave propagation and dissipation.

Broader impact
The phenomena explored and the analytical and numerical methods developed in this project are pertinent to many geophysical processes involving wave-wave and wave-mean flow interactions. An understanding and more accurate parameterization of the dynamics leading internal waves to break will significantly improve predictions of mixing locations in the ocean as well as enhance weather and climate predictions. The project also contributes to the development of practical and general ray-tracing algorithms, with the capability to quickly and

efficiently compute wave amplitudes in the presence of strong wave refraction, turning points, and other singularities, resulting in better wave dissipation estimates which can be used in larger scale models. This work will lead to a transformation of current modeling and prediction techniques, resulting in more efficient, broader calculations which are necessary to capture the extensive activity of internal waves in the ocean and atmosphere. On the educational side, the proposed investigation will allow for funding of a research program of a professor from an under-represented group and training of graduate and undergraduate students in the ideas, concepts and practice of fluid dynamics, oceanography, atmospheric sciences, internal wave theory, ray methods, data analysis and large-scale numerical simulation techniques.

The research will also be highlighted in high school outreach activities, a new graduate Environmental Fluid Dynamics course being created by the PI, and an undergraduate short course. The short course, designed as a part of this research, will emphasize the dynamics of these common but unseen waves through classroom instruction, experiments, and ongoing research opportunities.