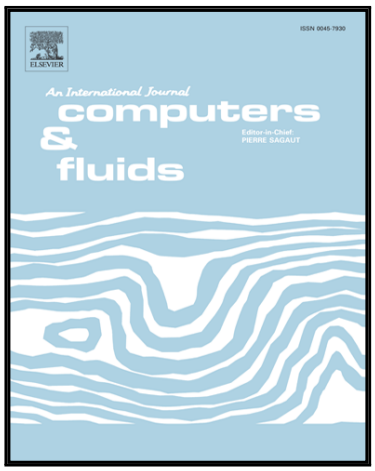

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A new variational multiscale formulation for stratified incompressible turbulent flows

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Abstract

For geophysical and environmental flows in the high-Reynolds-number regime, stable density stratification strongly affects the turbulent fluid motions. While turbulent flows, due to the presence of a cascade of spatial and temporal scales, present several challenges to accurate numerical approximation, density stratification in these flows exacerbates the situation further by suppressing vertical velocity fluctuations thereby enhancing the anisotropy of the turbulence. In this paper, based on the framework of residual-based variational multiscale (RBVMS) methods, we design a new numerical formulation for incompressible stratified flows that introduces coupling between the velocity fine scales and density-equation residual, and gives improved numerical performance as evidenced by the results of two challenging turbulent-flow simulations.

Keywords: Density-stratified flows, Turbulent channel flow, Self-propelled wake, RBVMS, IGA, FEM

1. Introduction

Many geophysical flows in lakes, reservoirs, coastal waters, and atmosphere involve a vertically stratified fluid. Because of their ubiquity in nature, their mathematical complexity, and the challenges involved in their numerical approximation, stratified flows are of great research as well as practical interest in such areas as geophysical fluid dynamics and wind energy. Of particular interest here are stable boundary layers which can be generated, for example, by the

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