Aerospace Engineering Doctoral Defense

A Dual Scale Approach to Modeling Hydrodynamic Instabilities on a Phase Interface

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Abstract

Advancements to a dual-scale Large Eddy Simulation (LES) modeling approach for turbulent phase interfaces are presented. In the dual-scale LES approach, a high-resolution auxiliary grid, used to capture phase interface dynamics, is superimposed with an LES grid that solves the filtered Navier-Stokes equations. An exact closure of the sub-filter interface terms is provided by explicitly filtering the fully resolved quantities from the auxiliary grid. Reconstructing a fully resolved velocity field to advance the phase interface requires modeling shear and accelerational instabilities on the sub-filter scale. A novel Volume-of-Fluid (VoF) vortex sheet method is proposed to model these sub-filter hydrodynamic instabilities. The VoF vortex sheet method is tested with a variety of classical hydrodynamic instability problems, compared against prior work and linear theory, and verified using Direct Numerical Simulations (DNS). An LES consistent approach to coupling the VoF vortex sheet with the LES filtered equations is presented and tested against DNS. Additionally, a phase change model is proposed and assessed in the dual-scale LES framework with an evaporating interface subjected to decaying homogeneous isotropic turbulence. Results are compared against DNS and the interplay between surface tension forces and evaporation are explored.

April 13, 2023; 1 PM; ERC 490;

Zoom Link: https://asu.zoom.us/j/2338609724