The effect of the boundaries in the stratified inclined duct

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Award date:
2023

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The stratified inclined duct (SID) is a common way to study the onset and behaviour of stratified turbulence. In this setup, a duct is placed under an angle with respect to the horizontal between two tanks filled with fluid of different densities. In the SID, different flow regimes can be identified, ranging from laminar flows to flows exhibiting Holmboe waves or (intermittent) turbulence. The prediction of these regimes has proven difficult, and especially, the role of the sidewalls and edges is still unknown. Two-dimensional (2D) simulations were done to study the flow behaviour inside the SID. These simulations showed good agreement with the analytical solution by Duran-Matute et al. (2023), but the 2D flow is generally more unstable than three-dimensional (3D) experiments. However, the overall flow behaviour follows similar patterns in both 2D and 3D, with most notably the characteristic intermittent turbulence found in the SID also being present in 2D simulations. To explain this increased instability and gain insight into the role of sidewalls in the SID, solution by Duran-Matute et al. (2023) is extended to a 3D flow. Several key differences between the 2D and 3D solution are presented. From this solution, regime transitions and the general behaviour of the flow were be predicted. This solution was also used to parametrize the effect of the sidewall friction in 2D, with good agreement with experimental results. The 2D simulations were also used to gain insight into the effect of the edge shape of the duct on the flow. It was found that this has no major stabilizing or destabilizing effect. In cases with rounded edges, the duct is found to be effectively slightly longer than in the case with square edges, but this difference is too small to have a major impact on the behaviour of the flow.