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Skin-friction drag reduction in buoyant bubbly plane Couette flow CHONG SHEN NG, KAI LEONG CHONG, HAORAN LIU, NAOKI HORI, University of Twente, Enschede, Netherlands, ROBERTO VERZICCO, University of Rome 'Tor Vergata', Roma, Italy, DETLEF LOHSE, University of Twente, Enschede, Netherlands — In surface flows, bubbles or air layers can reduce the effective density of the liquid. With a reduced effective density, the surface drag can be reduced, which is why the addition of bubbles or an air layer are attractive methods to achieve drag reduction. However, the role of buoyancy of the air on bubbly drag reduction are unknown. Here we show that highly buoyant bubbles in a plane Couette flow tend to form air layers and lead to skin-friction drag reduction of up to 20%. The datasets are obtained from direct numerical simulations of bubbly flow using the phase field method, with over two decades of Froude numbers at a friction Reynolds number of 180. We found that by gradually increasing buoyancy relative to fluid inertia, that is, by reducing the Froude number, bubbles will preferentially concentrate to the surface away from gravity. At a critical Froude value, the bubbly flow catastrophically converts to an air-layer flow. At this point, skin-friction drag at the air-layer side is reduced by 10-20%. Remarkably, the skin-friction drag at the water-layer side remains largely unaffected. Our results demonstrate that favorable bubbly drag reduction occurs when an ideal ratio between buoyancy and inertia is met in plane Couette flow.

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