"Control of boundary-layer separation using surface roughness"

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Abstract. Boundary-layer separation is the detachment of a viscous boundary layer from the body surface. In most cases, this phenomenon is considered detrimental as it actively promotes transition to turbulence. Therefore, the ability of controlling it is considered crucial in many engineering applications. As flow separation occurs at the solid-fluid interface, it became natural to investigate the behaviour of fluids near a solid surface. In most research studies a no-slip condition is imposed: the fluid sticks to the surface. However, recent investigations have considered a more realistic scenario, where the fluid slips past the surface. The main question is to determine whether replacing the usual no-slip boundary conditions with certain slip conditions may benefit the control of boundary-layer separation.

First, a linear stability study on slip channel flows is undertaken. The surfaces are modelled exploiting a linear Navier slip condition imposed on the channel walls. The linearised stability of the flow is investigated via an Orr–Sommerfeld normal-mode approach, the numerical solution of which allows us to determine the level of slip at which the flow is stabilised, for all flow Reynolds numbers.

Second, a numerical study on the effect of surface slip on the two-dimensional flow in a constricted channel is presented. The constriction is provided by a bump, upon which a Robin-type slip boundary condition is imposed. The effect of slip on the separation bubble dynamics occurring behind the bump is investigated. It is shown that surface slip attenuates the intensity of separation, delays the onset of separation, and reduces the separation bubble dimensions. Furthermore, slip is found to reduce the total drag over the constricted channel. Ultimately, slip inhibits flow separation.