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Non-equilibrium and transient processes in under-expanded volcanic jets

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During explosive eruptions, flow conditions in volcanic conduits can produce choked-flow conditions, or more generally conditions with pressure higher than atmospheric, at the volcanic vent. Under such conditions, the formation of supersonic structures (e.g. normal and oblique shock waves) in under-expanded jets has been postulated on the basis of experimental, theoretical and computational studies. In this work, we have investigated such features of volcanic jets by considering the transient and non-equilibrium multiphase flow behavior of the eruptive mixture. In fact, eruptive mixtures consist of pyroclasts of very different sizes which show remarkably different responses to the expansion dynamics. 2D and 3D numerical simulations have been carried out with an improved version of the transient non-homogeneous multiphase flow model PDAC (Esposti Ongaro et al., Parallel Computing, 33, 2007). In particular, a second-order time discretization was introduced and a fully multidimensional advection scheme was employed for mass and momentum transport, thus significantly reducing the amount of numerical diffusion and allowing to achieve more accurate results at a lower computational cost. Validation tests accurately reproduce the main features of homogeneous supersonic jets at the laboratory scale. For non-homogeneous mixture and assuming steady-state conditions at the source, computational experiments, at both laboratory and natural scale, highlight significant multiphase effects, such as shock wave thickening and lateral surging of the flow. Ongoing work is being devoted to the simulation of shock formation and evolution in volcanic jets by assuming time-dependent vent conditions as representative of Vulcanian explosions.