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# Understanding the dynamics of unsteady buoyant Jets: an experimental analogue of Vulcanian and Strombolian style eruptions

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Explosive volcanic eruptions, which are characterized by the discharge of ash and gas from the vent into the atmosphere, are an example of a naturally occurring buoyant jet. These buoyant jets can significantly impact the surrounding environment; for example, the presence of fine ash particles in the atmosphere can damage aircraft engines, potentially leading to engine failure. Therefore, during an explosive eruption, volcanic ash advisory centers (VAACs) consistently monitor the concentration of ash in the atmosphere using numerical models. These numerical models require the definition of a source term (i.e., source mass eruption rate, plume height and total grain size distribution), which is often obtained from simpler one-dimensional models. One-dimensional models derived from well-established theories successfully replicate the dynamics of the initial buoyant jet; however, they assume time-averaged source conditions which are not observed in field-scale vulcanian and strombolian style eruptions. As such, there is a disconnect between these well-established theories assuming time averaged source conditions and reality. This disconnect may introduce uncertainties in ash concentration forecasts, potentially resulting in practical implications such as unnecessary airspace closures or flights operating in hazardous conditions. The present contribution utilizes scaled laboratory experiments to quantify the influence of source variability on the dynamics of buoyant jets and evaluates potential deviations from time-average assumptions.

Scaled laboratory experiments were conducted in an acrylic tank measuring 1200x670x450 mm, filled with water to a depth of 870 mm. A vertical pipe, 18 mm in diameter, was used to release fresh water (density $\rho$ = 1000 kg/$m^3$), which was combined with dye or particles, into saline water (ambient density = 1000 - 1030 kg/$m^3$). This configuration resulted in the generation of a vertical buoyant jet. The flow rate was controlled and measured using a valve and ultrasonic flow meter. For the generation of unsteady discharges, a solenoid valve was employed, facilitating pulsed source conditions with discharge intervals ranging between ½ second to 2 seconds. Image analysis techniques, specifically light-induced fluorescence (LIF) and particle image velocimetry (PIV), were employed to measure buoyant jet characteristics, including concentration profiles, velocity fields, and jet geometry. These characteristics were measured under both steady and unsteady source conditions, facilitating a comparative analysis of the changes in behaviour arising from source condition variations.

The experimental results were compared with integral assumptions of one-dimensional models. These findings will be presented, and their significance will be explored within the context of vulcanian and strombolian style eruptions.