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A laboratory study of plumes associated with pyroclastic density currents

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Volcanic plumes associated with propagating pyroclastic density currents can rise tens of kilometers into the atmosphere, dispersing fine ash particles over large areas with a potential hazard for aviation safety. Such plumes originate from the buoyancy reversal of the pyroclastic density currents caused by the entrainment and heating of ambient air combined with the sedimentation of coarse particles. Several experimental and numerical studies investigated the formation, dynamics and impacts of these plumes but the mechanisms controlling the mass partitioning between the buoyant rising plume and the dense propagating current have received less attention despite its crucial importance for hazard assessment. Here, we present a new laboratory study aimed at investigating the controls on the mass partitioning during the plume lift-off. The experimental set-up is designed to simulate a gravity current of ethanol and ethylene glycol (EEG) flowing under a sloping roof in a tank of fresh water. The EEG mixture is less dense than fresh water but may become denser when mixed with water allowing us to generate a plume associated with the gravity current. Depending on the source conditions, the turbulent gravity current may either fully lift-off to form a buoyant plume, separate in a dense propagating flow and a buoyant plume, or propagate along the slope with no plume formation. We show that the transition between the three regimes is strongly controlled by the Richardson number defined at the source and by the slope. The results are consistent with the theoretical predictions of a simple 1D model and provide constraints on the mass partitioning during the formation of the plume.