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Laboratory studies of pyroclastic flows that interact with topography

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We performed a set of scaled laboratory experiments to simulate pyroclastic density currents (PDCs) using dilute mixtures of warm talc powder in air. The experiments were designed to evaluate the effects of topography on current runout, buoyancy reversal and liftoff, and mass partitioning into buoyant plumes. The densimetric and thermal Richardson, Froude, Stokes, and settling numbers for our experiments match those of PDCs and the laboratory currents are fully turbulent, although the experiments have lower Reynolds numbers than PDCs, thus our experiments are dynamically similar to natural currents. Comparisons of currents traversing flat topography or encountering barriers shows that runout distance is not significantly reduced for currents that traverse barriers with height less than 1.5 times the current thickness, but currents do not pass taller barriers. Buoyancy reversals occur in most currents, resulting in liftoff and generation of a buoyant plume. Liftoff occurs near the maximum runout distance for currents traveling over flat topography, but is focused near or above barriers for currents that encounter barriers. Notably, plume formation above barriers can result in reversal of flow direction downstream of the obstruction as portions of the current flow back and feed the rising plume. Greater than half of the initial particle mass composing the density currents usually partitions into the buoyant plumes; that fraction is greater for currents that liftoff closer to the source, thus topographic barriers increase mass partitioning from currents into buoyant plumes.