The dynamics of pyroclastic density currents: experimental insights

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We model dilute pyroclastic density currents (PDCs) using scaled, warm, particle-laden density currents in a large air-filled tank (described in Andrews and Manga, JVGR 2012). The currents comprise heated particles turbulently suspended in air. As the currents are initially denser and warmer than the ambient fluid, buoyancy reversals can occur when the currents have sedimented enough particles or entrained and heated enough air to become less dense than the atmosphere. Our experiments demonstrate the effects of thermal energy, atmospheric stratification, topography, and substrate roughness on current runout, liftoff, coignimbrite mass fraction, and sedimentation processes. In general:

1) cold currents travel farther and fractionate less mass into coignimbrite plumes;

2) topographic barriers must be >1.5 times as tall as current thickness to reduce runout distance, but barriers do focus plume liftoff;

3) substrate roughness increases runout until the roughness is comparable to the thickness of the turbulent lower layer of the current;

4) portions of currents can reverse direction during coignimbrite plume liftoff;

5) sedimentation rate is not steady but is instead coupled to and tracks large eddies moving along the bases of the currents.

Comparison of relevant bulk properties (Reynolds number, densimetric and thermal Richardson numbers, excess buoyant thermal energy density) and turbulent properties (Stokes and settling numbers) between our experiments and natural dilute PDCs indicates that we are accurately modeling at least the large scale behaviors and dynamics of dilute PDCs.