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Pyroclastic density currents: state of the art and perspectives

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Pyroclastic density currents (PDCs) are among the most amazing, complex and dangerous volcanic phenomena. They are moving mixtures of particles and gas that flow across the ground, and originate in different ways and from various sources, during explosive eruptions or gravity-driven collapse of domes. They may be short-lived (highly unsteady) or relatively long-lived (sustained unsteady to quasi-steady) phenomena, driven by both magmatic or phreatomagmatic melt fragmentation. From a fluid dynamic point of view, PDCs macroscopically behave as dense fluids (the pyroclastic mixture) immersed in a less dense, almost isotropic one (the atmosphere). They mainly move under the effect of gravity and their mobility (distance travelled vs. difference in height from source and deposit) is greatly controlled by mass and height of generation (potential energy) and efficiency of conversion from potential to kinetic energy (i.e. loss of momentum due to frictional processes both within the current and at current edges). Because mass and frictional processes mainly relate to solid particles, the particle concentration in a PDC is crucial in determining the physical parameters of the moving flow (i.e. velocity, density, clast-support mechanisms). This presentation is an exploratory effort to address some key concepts about physical processes that influence the mobility, sedimentology and depositional mechanisms of PDCs. The state of the art about PDC dynamics and deposition is discussed using recent advances if field sedimentology, large-scale laboratory experiments and numerical simulations. Recent field studies proposed sedimentological models that consider the different typologies within a continuum spectrum that spans from very dilute (fluid-dominated) to very concentrated (solid-dominated) flows. These models have been recently validated through large-scale laboratory experiments (for both diluted and concentrated flows), which also provided precious inputs for improvement of numerical models. By their side, numerical codes experienced in the last years an enormous step forward to physical conditions closer to the natural phenomena. Of particular interest is the incremental use of Lagrangian codes that allow the tracking of solid particle trajectories and the observation of their deposition.