Skalenkaskaden in komplexen Systemen

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Volcanic plumes and particle sedimentation

Abstract:

Powerful explosive eruptions are typically associated with sub-vertical or bent-over volcanic plumes that can inject large quantities of gases and particles of various sizes and shapes into the atmosphere, altogether known as tephra. Tephra consists of different components with variable density of both juvenile (fresh magma) and lithic (wall rock) nature and can vary from meter-size blocks and bombs, which are ejected from the vent as ballistics falling within a few kilometres from the source, to micron-size particles, which can be transported by atmospheric winds at continental or global scales. Residence time in the atmosphere mostly depends on particle drag and sedimentation dynamics. Tephra particles may sediment individually, clustered in various types of aggregates or entrapped within sedimentation instabilities and, depending on their sizes, represent different hazards. In particular, impact of ballistic blocks and bombs can significantly damage infrastructure close to the vent; accumulation of lapilli and ash can cause a wide range of damage to communities and ecosystems, while fine ash (<63 μm) can jeopardize civil aviation and the finest micrometric particles can also threat human health. Depending on the ratio of horizontal wind velocity to plume rise velocity, volcanic plumes can develop as strong (sub-vertical) or weak (bent-over) and eventually reach the Neutral Buoyancy Level (NBL) where their density equals that of the surrounding atmosphere, and start

spreading laterally around this level. When the rising plume velocity is significantly larger than the horizontal wind velocity, the plume rises beyond the NBL because of momentum at the top of the plume and, from there, collapses toward the NBL spreading as a gravity current to form an umbrella cloud. Our understanding of both plume dynamics and particle sedimentation is crucial to the characterization of volcanic systems and to an accurate forecasting of the associated hazards and mitigation of risk. Given the complexity of the physical processes, best insights result from a combination of field, experimental, theoretical and numerical studies.