GRAVITATIONAL INSTABILITIES IN VOLCANIC ASH DEPOSITION : THEIR ROLE AND THEIR DYNAMICS

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Volcanic ash is a significant hazard for areas close to volcanoes and for aviation. Gravitational instabilities forming at the bottom of spreading volcanic clouds have been observed in many explosive eruptions. For the first time here, we characterize the dynamics of gravitational instabilities from analysis of video imagery from the 2010 eruption of Eyjafjallajökull (Iceland) and field observations of the associated tephra accumulation (Bonadonna et al. [1]) in combination with insights from dedicated laboratory analogue experiments. We analyzed the propagation of fingers recorded using high-resolution video (see Fig. 1) taken on 4th May 2010 (12:49:21 GMT) at a position 7.7 km south of the vent (0568182E, 7047683N). Gravitational instabilities initially took the form of downward-propagating fingers that formed continuously at the base of the cloud, and appeared to be advected passively at the crosswind speed. Measurements of finger propagation are consistent with initial conditions inferred from previous studies of ash cloud dynamics. Our observations challenge the view that aggregation is the primary explanation of proximal fine ash sedimentation, and give direct support for the role of gravitational instabilities in providing regions of high particle concentration that can promote aggregation.

We also developed dedicated laboratory analogue experiments similar to that of Hoyal et al. [4] with an aqueous suspension of particle-laden fluid initially overlying a higher density sugar solution. Two main experimental campaigns have ben carried out, the first one to investigate the evolution of particle concentration in the mixing region that results from propagation of gravitational instabilities and the second one to study the effect of particle size, composition and concentration on finger dynamics and generation. The experimental set-up consisted of a Plexiglas tank of 50 x 30.3 x 7.5 cm equipped with a removable banner for the partition of the two separate layers. In the first series of experiments we used Glass Beads of a diameter range of 45-63 μm, in the second one we used particles of different composition: i.e. Glass Beads with three different diameter range '< 32 μm', '45-63 μm', and '63-90 μm' and Andesitic, Rhyolitic, and Basaltic Volcanic Ash with diameter range of '< 32 μm', '45-63 μm', '63-90 μm', '90-125 μm', '125-180 μm' and '> 180 μm'. Three initial particle concentrations in the upper layer were employed: 3 g/l, 4 g/l and 5 g/l. Results show that finger downward propagation significantly exceeded the settling speed of individual particles, demonstrating that gravitational instabilities provide a possible mechanism for enhanced sedimentation of fine ash and confirming what also suggested by Carazzo and Jellinek [2, 3]. In addition analysis of the finger dynamics show that the number and the speed of fingers increase with particle concentration and the speed increases with particles size while it is independent on particle composition.

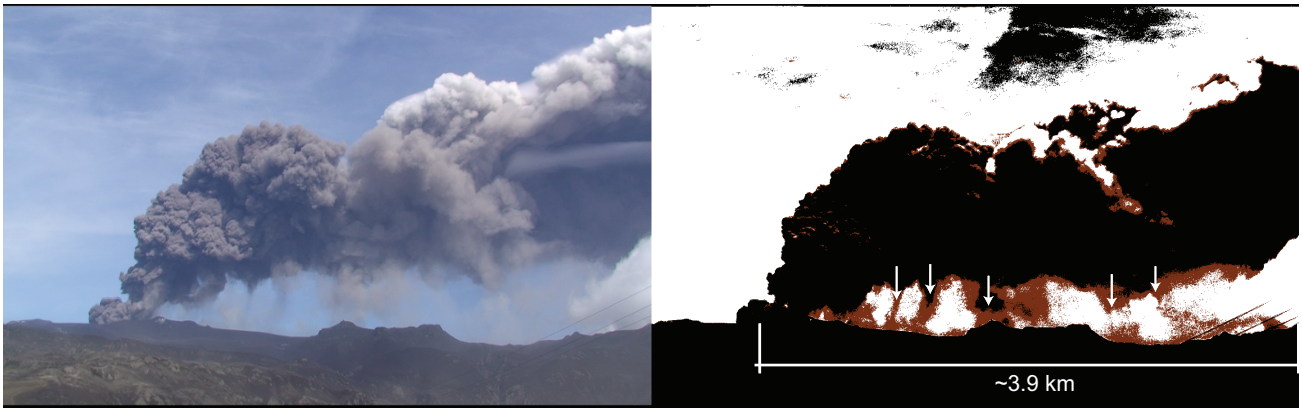

Figure 1. Original and processed snapshot of the video of the Eyafjallajökull plume as observed on 4th May 2010. Finger position is indicated with white arrows (from Manzella et al [5]).

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